THE TALKIES

JOHN SCOTLAND

WITH A FOREWORD BY CECIL M. HEPWORTH

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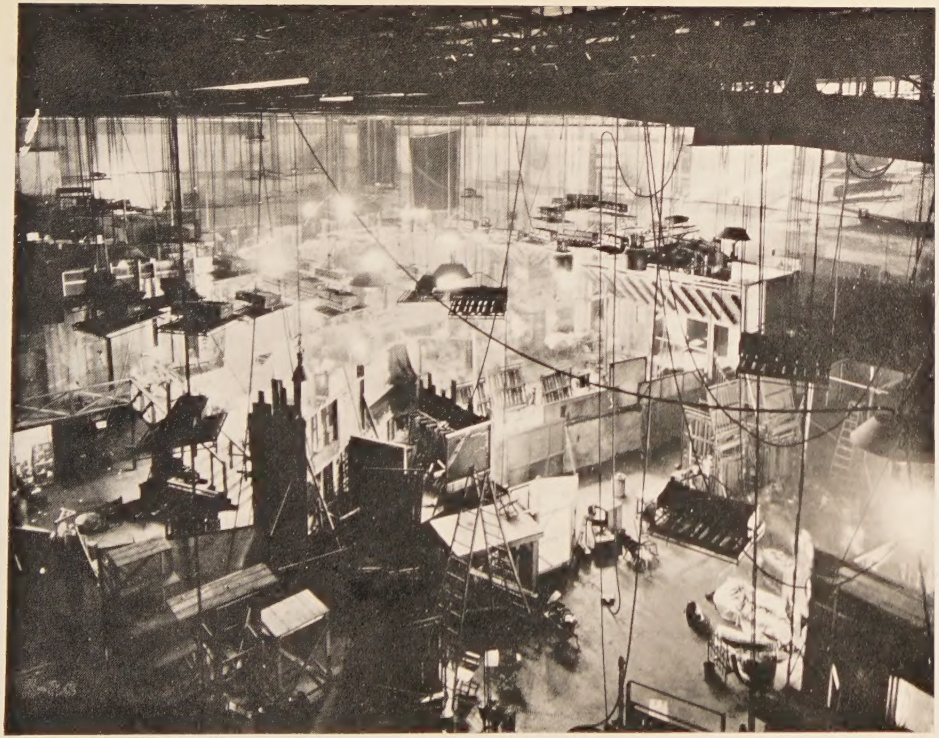

A "Noisy Studio" where "Silent" Pictures were made.

[*Courtesy of Paramount Famous-Lasky (America).*

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BY

JOHN SCOTLAND

WITH A FOREWORD BY

CECIL M. HEPWORTH

LONDON

CROSBY LOCKWOOD AND SON

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AUTHOR'S PREFACE

I WISH firstly to thank my friend Mr. Leslie Eveleigh, F.R.P.S., for his continuous help and co-operation. Without his knowledge of every branch of the cinema industry this book could never have taken the form that it has.

Then there is Mr. H. V. Whitehouse, one of that little band of distinguished though amateur scientists who even before Frieze-Greene was turning the handle of his first camera were pouring out both time and money in their passionate belief that true colour photography would eventually become a practical proposition and who have contributed so much to the industry of to-day.

Finally, I want to thank Mr. Cecil Hepworth for writing the Foreword. There is little that I can say to him except that I count myself fortunate indeed to have even so much as two lines from his pen inside the covers of this book.

JOHN SCOTLAND

FOREWORD

WHY the author or authors of this book should have been prompted to conceal his, her, or their identity under a false name is not for me to guess, but I propose to give the show away to this extent: the pseudonym is not a cloak for ignorance, as pseudonyms sometimes are, but covers, in fact, a fund of intimate knowledge of silent pictures from before the war and of talking machines from the days when those egregious instruments had scarcely dreamed of a union with cinematography.

To me the most remarkable thing about this union is the speed and completeness with which it has been accomplished. Until two or three years ago the high contracting parties were completely aloof from one another, and although from time to time there were rumours of an engagement, it was not until quite recently that the mating took place. Moreover, it would seem that although the marriage appears to have been arranged in America, there is not the remotest likelihood of a divorce. I am not going to be inveigled into an invidious guess as to which of the protagonists is the better half, although there are some who are ungallant enough to suggest that the mere

name "talking machine" is sufficient indication of sex.

It must be remembered that the two have been flirting for years. Long before the war the gossips were busy with rumours of entanglements which resulted in the birth of the Cinephone and the Vivaphone and other strange hybrids, but now that the real marriage has taken place it is natural that these youthful indiscretions should be forgotten.

I begin to feel that I shall be on safer ground if I do not pursue this image any further, for I want to allude to some of these early efforts without having to call them by an unkind name. I am speaking of pre-wireless days when no one had dreamed of amplification by valves and the gramophone had to stand upon the platform where the screen was, remote from the operating box. The problem was to keep synchronism between two machines that were so far apart. In Barker's Cinephone the talking machine had an illuminated disc with a hand travelling over it, and in the corner of the projected picture was the photograph of a similar disc which had been part of the scene when the film was taken. If the operator in the box could turn his handle at such a speed as to keep the projected index finger

exactly in step with that on the gramophone his picture would synchronize with the sound. He had to be clever to be successful. But it did not matter very much, for the audience got so interested in watching his efforts that they forgot to listen.

In the Vivaphone—for which I was responsible—the connection was electrical. A periodic impulse from the distant gramophone was associated with a similar electrical impulse from the projector. These impulses acted in opposite directions upon a single needle, so that it remained stationary as long as synchronism was maintained, but gave instant warning if it were in danger of being lost. There was another fearsome device whose name I have forgotten, in which a kind of cardan shaft ran the whole length of the hall from the projection booth to the gramophone, and the records of the patent office bristle with other optimisms of inventors who were before their time.

But all of these devices, however successful, were foredoomed to a short life, for they were based upon a kind of fallacy. They all took existing gramophone records and made films to synchronize with them, and it was obvious from the start that the supply of records of a sufficiently

suitable character must soon come to an end. But there was one invention which I remember appealed to me very much because it was free from this objection, and the picture and the sound-record were made simultaneously. I forget what the device was called, but it came out under the ægis of Leon-Gaumont of Paris. One of the results I remember was the crowing of a cock, which is not what you would call an enthralling drama in itself, but was completely convincing as to the method used, for you could not introduce a cock to the record of his own crow and ask him to do it again in perfect synchronism. It is to be presumed that these early manifestations came to an untimely end for want of the thermionic valve, for it is indisputable that the means of amplification, first evolved for the benefit of radio, was the vital spark which brought the talkies into being.

It is interesting to recall that Edison's invention of the talking machine was the result of his effort to give sound to his kinetoscope pictures. You gazed into a peep-hole for the view and put "cheese-tasters" in your ears for the sound, and there you were. But the people went crazy over the picture and disregarded the dialogue, and so it happened that the two became separated in

the very beginning, and it was not until thirty years later that ten thousand inventors set to work to bring them together again.

That the talkies have come to stay there is not the slightest room for doubt, and I suppose that most people are well satisfied that it should be so. The perfection which they have attained in the very few years of their union gives promise of the development of a really valuable medium of expression when its artistic possibilities are as well understood as its physical difficulties. But it may perhaps be permitted to a veteran to regret the passing of the silent film, for many years and much labour and treasure had been expended in the attempt at its perfecting, and a little progress had been made which now has gone for nothing. Sad to remember that the silent picture had an opportunity which it never really developed. Some hint of its potentialities was given in such films as "Nanook of the North" and "Chang," and a few others—films which got a glimpse of vast tracts of open spaces and seas and mountains, and called the very forces of nature, storms and flood and frost and savage beasts to be their actors. But the opportunity for real greatness was scarcely touched, and producers who had the whole world for an arena preferred the easier

way—a puppet-show in a closed-in studio. And now the opportunity has gone. Perhaps there will be another quite as good to take its place—let us hope so, anyway. The king is dead. Long live the king!

CECIL M. HEPWORTH

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THE TALKIES

CHAPTER ONE

DEVELOPMENT OF THE SOUND FILM

Everybody has been talking Talkies; all sorts of things have been written about them. Some people like them, others say that they will be a thing of the past in five years' time. On the other hand many declare that they are the most tremendous advance in public entertainment that has ever been achieved. They came, too, at a time when those engaged in the Motion-Picture industry were beginning uneasily to wonder whether the silent film was not approaching the saturation point of progress. More and more money was being poured out in magnificent theatres and palatial surroundings, with the addition of stunt lighting and very expensive Star Bands and Variety Artists, in an endeavour to negative the suggestion that the day was not far off when the public would begin to ask, marble fountains or no marble fountains, whether there were not some other form of entertainment to satisfy their craving for novelty and new emotional

experiences. The whole industry was, with only a few exceptions, on the verge of bankruptcy.

Both got what they wanted, and the Talkies have certainly stirred up not only the public but the Motion-Picture folk as well. Angel-faced beauties and strong, silent men were reported to be packing their bags and stealing away from Hollywood, because, in spite of eyes like stars and masterful chins, nature had endowed them with a voice like a corncrake or an accent that could be cut with a knife. Some even now are reported to be taking time by the forelock and spending their now too frequent "Rests" in the salons of the voice production experts.

Whatever such rumours are worth, one is certainly true. The Talkies have entirely altered methods of production built up after years of experience.

The speed of action of Talking Pictures is entirely different from that of the silent dramas. The pace of the latter is terrific. Anyone who wants to prove this has only to put his watch to his ear and count the seconds as scene after scene flashes by on the screen. Very few "shots" last more than fifteen or twenty seconds.

Many scenarios have had to be entirely rewritten, and the art of film editing, a highly expert

business, has taken on an entirely different complexion. Film editing consists of cutting and arranging the various episodes with their captions and titles in a telling and effective sequence. With the silent drama it is perfectly possible to cut out many feet of film without distracting the eye of the audience; not so with the Talkies, however; the effect of taking out a scene and half a sentence with it would be disastrous! If that is necessary it all has to be done over again. A mere snip of the scissors and a nimble dab of film cement is no longer always possible.

The film actors are not the only folk who have been set by the ears: there is not a single department in film work which has not had to start on a whole series of new problems and adapt already known processes to the new art.

Producers, set designers, scenario writers, carpenters, electricians, and chemists all are hard at work trying to keep up with the Talkies which have burst upon the world so suddenly and have been hailed as the most marvellous invention of modern times.

But we must pause and think. Are they as new as all that? . . .

In the scramble to produce them, to go and see them, praise or blame them, we seem to have

forgotten to wonder who invented them, and whether or not some of the praise, anyhow, should not go to scientific workers, some of whom are long since dead, but who dreamed of Talkies and made their contribution of inventiveness and hard work to the bulging bank balances of the Talkie producers of to-day?

While it is the purpose of this book to take our readers behind the scenes a little and show them something of that side of film production which hardly, if ever, appears on the silver screen; into the studios and laboratories where they may see and learn something of the various processes and find out how the experts in their long white coats are tackling the hundreds of new problems with which they have been so suddenly confronted; is it fair to charge right ahead and forget the pioneers with their queer apparatus and their dreams and disappointments? Surely not!

A book could be written about any one of them. But you need not fear that you will be bored with dull figures or a mass of lecture jargon. All that can be done is to give honour where it is due and remind you that there is very little that is brand new in any modern development, except, perhaps, the glittering motor-cars of

those who have been fortunate enough to be in the business when the dreams of the old-time inventors have come true.

The idea is so old that it is lost in the "mists of antiquity." From time immemorial mankind has tried to produce speaking and moving representations of his fellows. Even the Egyptians are believed to have had a device for reflecting the images of men and women on to smoke screens by means of mirrors of polished metal from illuminated "studios" underground. Many a guilty miscreant has stammered out his or her confession before their relentless accusers as vision after vision floated before their terrified eyes, and accusing fingers singled them out for the hideous retribution they had to make.

The Greek Oracles did a roaring trade in mysterious utterances whispered through loud-speakers hewn, either by nature or by the officiating priests, out of the rock of the grottoes where their shrines were situated.

Coming to the 'eighties we find that in 1888 one hero, Mr. Le Prince, actually took a motion picture of his mother-in-law. It was not a very flattering portrait, but there is no doubt about the date at which it was taken and that it was a motion picture, because the august lady departed

this life in October of that year, and Mr. Will Day has a portion of the film.

It is indeed quite impossible to discuss the early history of motion pictures without mentioning Mr. Will Day's name, for it is his passionate devotion to the industry, with which his name has for so long been associated, that has prompted him to spend a fortune collecting every shred of material and information from the ends of the earth which could complete the chain of evidence which points unerringly to the fact that in the first place the history of the Movies is largely the history of English inventiveness, and in the second place that there would have been no history to talk about if it had not been for Mr. Will Day's devotion, some of the fruits of which are to be seen in his magnificent collection of historical Movie apparatus in the South Kensington Museum.

It is difficult not to wonder whether there is not an evil spirit that haunts the inventors of the film world. If there is, it was Mr. Le Prince who was the first to fall under its spell, For one day he bid good-bye to a friend at Dijon Station, stepped into the train, and from that moment to this has never been heard of, or, indeed, remembered except by a few enthusiasts who, headed

by E. Kilburn Scott, are proposing to put a tablet to his memory on his house in Leeds. His apparatus disappeared, too, as mysteriously as he did. But we do know how he made his picture.

He took a series of separate pictures with a weird and wonderful camera having a lens for each picture, and then mounted each picture separately on a long band, and triumphantly dragged the lot through a projector by means of perforations on one side of the strip which engaged in small points on the edge of the roller or sprocket which drew the strip through. Not even Mr. Day can tell what Mr. Le Prince's mother-in-law said when she saw herself on the screen. She may have been enthusiastic, then again she may not; one thing is quite certain, that her picture would not stand much chance of a record run if it appeared at a theatre now, because it was taken at the speed of only ten pictures per second instead of the sixteen or more pictures which are considered necessary now to lull our gullible optic nerve into a sense of reality.

The idea of passing the pictures before the lens in a strip was a most important advance. For while it is true that a number of people had laboriously built up a series of images on glass

discs and cylinders, this was the first hint of the form that motion-picture records were to take. It will not take much to ask the reader to believe that Thomas Edison was hot on the track of the motion-picture idea; he was, in fact, one of the glass-cylinder merchants in the same year, and shortly after made a record on a strip after the fashion of the Le Prince machine soon after that unfortunate gentleman so mysteriously disappeared.

A year before this, however, there was patented in America an idea of prime importance to the development of motion-picture films. An American clergyman, the Rev. Mr. Hannibal Goodwin, conceived the notion of using celluloid instead of glass for photographic plates, in such a way that a series of pictures could be photographed on to it without the necessity of making separate pictures and mounting them.

In the same year, however, someone in England was doing a lot of hard thinking about the idea of the motion picture; that was Mr. Frieze-Greene, who in his laboratory at Chelsea was laying the foundations of the motion picture as it is produced to-day. In 1888 he made a photographic film on paper soaked in a no less homely fluid than castor oil in order to make the paper suffi-

PLATE II.

THE FIRST APPARATUS TO MAKE A FILM—FRIEZE-GREENE'S COMPLETE OUTFIT.

[*Courtesy of Will Day, Esq.*

[*To face page* 8.

ciently transparent to show the pictures through, but he was not satisfied with this paper film and looked about for a more suitable "base" for his light-sensitive emulsion.

Finally, with the assistance of an expert chemist friend he produced the first celluloid motion-picture film, and made a picture of Hyde Park Corner, which was later exhibited at Chester in 1890.

In the meanwhile Edison, who heard of the Kodak Company's experiments with celluloid, sent post haste to Mr. Eastman for a strip of this new material.

Frieze-Greene had in the meanwhile, however, patented his invention, and there is no doubt whatever that he held the master patent for all moving pictures as they are produced to-day. Mr. Day has a fragment of one of his early films made of a scene in Chelsea.

Frieze-Greene was not to live to enjoy the fruits of his extraordinary invention or, indeed, of the many other brilliant ideas which emerged from his fertile brain. Misfortune struck him down as it eclipsed Le Prince and wellnigh crushed the pioneer Talkie inventor.

Space forbids us to describe either his other work or his remarkable cameras and projectors

with such a tragic history, for he neglected his business in the pursuit of the perfect movie machine and was thrown into prison for debt. While in gaol he suffered the final indignity of seeing his precious apparatus sold under the hammer for the paltry sum of 25 shillings to satisfy his creditors, who little realised that the bits and pieces that they were trundling away on their barrows were to become beyond price in so short a time.

Let it suffice to say that he died a pauper whose name is barely known to the millions who nightly crowd the cinemas of the world, rewarded only by a memorial erected in his honour by his colleagues in the industry he created.

In the meanwhile in America the indefatigable Edison was actually working on a Talkie, and in 1888 he hitched up to his picture cylinder one of the wax cylinders of his newly invented phonograph, and, to quote Mr. Ramsaye of the Pathé Exchange, New York, he produced "one cylinder of fairly good noises and one full of frightful pictures"; artistically the thing could hardly claim to be a success, but it does serve to show that the idea of the possibility of a Talkie is not by any means new, in fact a Talkie machine on these lines was actually made commercially.

EUGENE LAUSTE AND HIS ORIGINAL APPARATUS.

[Courtesy of "The Bioscope."

[To face page 11.

But owing to the fact that it was, like all the early disc or cylinder picture machines, merely a peep-show, which could only be viewed by one person at a time, it was not a success, and soon died a natural death.

We must turn once more to England in our search for the inventor of the Talking Film as we know it to-day.

Romantic as the story of the silent picture has been, the Talkies can claim a special page in the history of scientific development. That page was written in the records of the British Patent Office by Eugene Lauste twenty-three years ago.

Lauste had been working for years to combine the work of Herr Ruhmer (a German scientist) and Frieze-Greene; and he did succeed at length in devising a true Talking Film machine which worked satisfactorily. His work is an excellent example of the combination and patient development of already known facts; it had, for instance, been known for years that certain materials altered their electrical qualities under the influence of light. The discovery of the light-sensitive properties of selenium was romantic in the extreme, and burst quite unexpectedly on the world of science at a period which is distinguished for the production of discoveries which began to sever

the boundaries between what were then largely considered separate sciences, and began to show that no branch of science could be considered without its relationship to others.

Before the discovery of the light-sensitive properties of selenium there had only been the faintest suspicion that there could be any connection whatever between the activities of light, chemistry, and electricity, although the connection between light and chemistry was of course known to the early pioneers of the art of photography.

The fact that selenium, and, indeed, a number of other substances, would alter their resistance to the passage of an electric current under various degrees of illumination, was a discovery of the most momentous importance. It came about in this way:

There was in charge of the Transatlantic Cable Station at Valencia a certain Mr. May, an assistant of Professor Willoughby Smith; May noticed one day that the needles of his indicators were flickering in a manner that was quite unexplainable. He made a series of tests to see if anything were wrong or if an endeavour were being made to pass a message to him; but he was quite unable to account for these spasmodic and irregular move-

ments. In vain he examined every portion of his machine to trace the cause of these eerie signals from nowhere, and it was only by chance that he noticed that when he moved his hand in the air the needles nodded back to him. He walked over every inch of the room moving his hand slowly this way and that, until he found that it was when the shadow of his hand passed over certain portions of his apparatus that the mysterious movements began again.

He moved closer and closer to the table until he was able to identify the piece of apparatus that was behaving in so peculiar a manner; it was comprised of some electrical resistances made of selenium, known then only for its highly resistive qualities. May immediately communicated with his Chief, Professor Willoughby Smith, whose paper on the subject aroused the whole scientific world.

It was, however, Alexander Graham Bell, the inventor of the telephone, who first demonstrated the possibility of using light in the service of sound; the story of his experiment has come down to us as a graphic little anecdote which is unforgettable. Bell's idea was to mount a mirror on the diaphragm of one of his telephones and cause the vibrations of his voice to flicker a ray

of light so that it varied in intensity as it fell on to a small cell of selenium, known by that time to possess light-sensitive qualities. His transmitter was fixed in the window of a room in Washington, and was left in charge of his assistant, Mr. Tainter, while Bell walked over to the building where his receiving mirror and selenium cell was fixed.

At last Tainter, unable to contain himself, shouted to the machine: "Mr. Bell, Mr. Bell, if you can hear what I am saying come to the window and wave your hat!"

Bell, hearing these words as he picked up the receiving instrument, at once went to the window and was seen by his delighted friend frantically waving his hat with a beaming smile on his face. A small incident in itself, but little less dramatic than the historic moment when Bell called into the first telephone to his assistant: "Come up here. I want you," and waited breathlessly for the welcome sound of eager feet pounding up the stairs.

Bell is not alive to see the Talkies, but if there is a place where the inventors of the past are allowed to congregate and murmur to each other, "I told you so," and the question of Talkies crops up, he will be in good company.

I must not dally too long, however, over these

first birthdays of science. I must press on and mention again Herr Ruhmer, who achieved some astonishing successes with Light telephones, which were indeed the first wireless telephones.

Ruhmer succeeded in telephoning with a searchlight several miles; but he made another contribution to the Talkies which was much more important than that, for he actually succeeded in photographing on to a strip of film the vibrations of sound, and probably gave the idea to Lauste of this form of sound record. It was, however, left to the genius of this remarkable old gentleman to conceive and invent a machine which would combine the film sound record and the motion picture film.

Lauste's ingenuity was really extraordinary. When we come to discuss the various methods in use to-day, we shall realise that there was no fundamental feature of Talkie work that his British patents did not cover; they are indeed well worth quoting, for in their prosy official phraseology lies a romance of invention which was as extraordinary as it was unfortunate.

This invention (says the specification) relates to a new or improved cinematograph and phonographic method or process, and to means for recording and reproducing simultaneously the movements or motions of persons or

objects and the sounds produced by them . . . so that the impressions of the movements would be recorded simultaneously with the impression of the sound waves and *will be reproduced simultaneously and in exact synchronism* with them.

Here was the general idea, but as we read on we see that both the remote sound-recording camera, which we shall read about later, and the idea of the picture film with the sound-record printed along its edge, are clearly mentioned. Not only that, but the two methods of photographing sound are specified. Nothing, in fact, is left out which really matters.

We transmit the sound waves electrically from the place where the sounds originate to the place where we desire to have them recorded, and we record them photographically in varying degrees as to area, quantity, intensity and corresponding effect of light and shade proportioned to their period and amplitude, simultaneously with the recording photographically of the impressions or photographs of the successive movements of the objects, on separate parts or in separate positions of one or the same transparent medium or recording substance of material. . . . When such record is obtained we reproduce it by causing light to pass through that portion of the medium containing the record of the impressions and so project them on the screen, simultaneously causing light to pass through that portion of the medium containing the record of the sound-waves to a cell of selenium or other suitable substance by which the varying degrees of light and shade of the record are converted into correspondingly varying

electric currents, which are transmitted to the place where it is desired to reproduce them, and there converted into sound vibrations by a suitable vibrating medium.

What more astounding story could be told? What greater tragedy than that Lauste, financially ruined and broken in health, allowed his patents to lapse?

In the absence of the thermionic valve, Lauste tried every conceivable means, from singing flames to compressed air, to overcome the difficulty of amplifying his reproduced sounds. After vainly seeking financial support in this country and Europe, he went to America, where he made an effort to interest capitalists in his Talking Picture device, but his plans were thrown into chaos by America's entrance into the War, and he made no progress for some years. Disappointment had by this time broken his health, but he never lost faith in his invention, and in 1923 he entered into an agreement with someone in New York to finance the device. The best, however, that this financier could do was, to use Mr. Lauste's own words, "to string him along until 1926," when he again fell ill. It was during this illness that his financial agent persuaded him to move his machinery and instruments to more convenient premises. Later, however, the man disappeared, and Mr.

Lauste discovered that no rent had been paid, and that the whole of his plant had been mortgaged for $1,000.

The courage of inventors is proverbial, and Lauste is still working away in America on a new form of sound reproducing device, and, at the age of seventy-two, watches with interest the legal battles of the huge concerns in the Talkie world of to-day, the representatives of some of whom were frequent visitors to his laboratory while he was ill, years ago.

Some years before the War, still further activity was showing itself in England. Mr. Hepworth, a very early photographic pioneer and the inventor of the automatic development of cinema film, now used all over the world, succeeded in getting, anyhow, a plausible imitation of a Talkie by rather a different system called the Vivaphone.

He used to secure gramophone records of such famous artists as Vesta Tilley and Harry Lauder, and get them to sing in front of the camera with their records; these records were then synchronized with the resulting film by means of a most ingenious electrical signalling device up to the operating room. This was, however, not true synchronization, and although some measure of success was obtained, one occasionally beheld the

spectacle of the singer several words in front of the words coming from the gramophone, frequently due to the fact that the job of starting the gramophone was relegated to the program girl.

Some of our readers may remember those early pictures, for they were actually shown in a number of cinemas up and down the country, and hundreds of short films were made, including two of particular interest. A good deal of use has been made recently of the talking film for political purposes, and this type of propaganda work has been hailed as the very latest device for persuading the electorate to do as they are told.

Mr. Hepworth was before them all, however, with two talkies made many years ago, one of Lord Birkenhead—then F. E. Smith—and the other of the late Mr. Bonar Law, both of whom were dilating on Tariff Reform!

Although Mr. Hepworth actually went so far as to take his artists down to the "His Master's Voice" studios to have special records made for his device, his pictures were not a prolonged success, largely because, in addition to the fact that the synchronization was not good, there existed, at that time, no satisfactory method of amplifying the sound of the gramophone, although mention should be made of Tomassin's

Animatophone and a wonderful compressed air sound device called the Stentophone, which made its appearance shortly afterwards.

Mr. Hepworth was, however, able to sell the rights of his invention to America for a considerable sum, and it is of interest to remember that the first universally successful talkies—*The Singing Fool* and *The Jazz Singer*—were recorded on the Vitaphone system, Mr. Hepworth's device having been called the Vivaphone.

It is, however, of great interest to note that the idea of applying voices to existing films has of late been greatly developed, and in a most ingenious manner, and that this phase of Talkie activity has come to the rescue of many who were landed with large stocks of silent films.

A great deal of experimental work was done both in America and in Europe, and had it not been for the lack of means of making the whispered message of the photo cells loud enough, there is no doubt that Talkies would have come ten years ago, because a great deal of interest was being taken in the idea about that time.

It is true that various efforts had been made to devise sound amplifiers, and a good deal of that work was done in an effort to make microphones which would control sufficiently large power to

make long-distance wireless telephony possible. I believe that as many as thirty microphones coupled up together were used when the first words were radioed across the Atlantic.

A great deal of ingenuity was expended in this direction, and some microphones were used experimentally which would control electric currents equivalent to many horse-power, using various liquids to keep them from catching fire.

Another way of attacking the problem was to make use of an effect which had been noticed some years previously, and which had been used in attempts to increase the range of searchlight telephones similar to those of Herr Ruhmer and others.

The principle involved was roughly as follows:

Quite a small microphone was associated in a special way with an electric arc-light, which had been arranged so that it would generate the oscillations necessary to transmit a wireless wave; variations in the microphone, which was connected to the arc-light, caused certain changes in the electrical condition of the space between the two carbon rods from which the familiar brilliant glow emerges. Words spoken into the microphone caused sympathetic variations in the strength of the wireless wave emitted by the arc.

This idea is worth mentioning because it was the subject of a determined attempt to produce a Talking Picture in 1921, after the War which called a halt on so many promising lines of research, and hastened the development of others less worthy of attention.

An American, Mr. Delmar Whitson, was the hero of this latest endeavour, and he was as unfortunate as the others, as we shall see; but through no fault of the system which he devised.

Whitson was attracted by the success of Ruhmer's work in recording sound on film, and tried to do the same by using the light from a speaking arc, as it was called, the light from which he focused through a series of lenses and a narrow slit on to the passing film. Most of us have noticed how the arc-lamps, which were, until recently, used for street lighting, spluttered: Whitson was seriously bothered by this. The smallest amount of spluttering was, of course, fatal to his work, as it was immediately photographed on to the film. Whitson did not have the benefit of photo-electric cells, and he very soon found out that the selenium cells which he was able to procure or make suffered from the faults already mentioned, and, in addition, were themselves a source of troublesome noises, which he was not able to

cure. He tried every conceivable idea which could possibly have any value for his work, and exploited every known method of modulating or shuttering his recording light.

He did some valuable work with light "valves," formed of certain liquids, which were known to affect the passage of light through them when they were subjected to varying electrical pressures. He tried, too, to make use of the knowledge that some materials will twist a ray of light under certain electrical conditions, and, quite apart from the fact that the conclusions that he reached were of the utmost value to other experimenters who followed him, he did succeed in producing a very tolerable Talking Picture as soon as he was able to make use of the then newly invented amplifier valve to render his speech and music audible to a large audience.

It will be of interest to wireless "fans" to know that he actually made a moving coil loudspeaker many years before it found a more universal use in radio broadcasting.

Whitson was no more lucky with the Movie magnates of the day whom he approached with his invention than were other inventors. Not because his machine was defective in any way, but simply and solely because they did not see

why they should bother with any further complications to their work, which was already making as much money as they could turn over in twenty-four hours.

Not for the first time a deserving idea was ignored while the financiers stacked up their money-bags, and it was not until the shadow of bankruptcy was beginning to darken the interiors of their palatial homes that they sought desperately for some new and startling line of activity, and poured every remaining cent that they could raise into the production of the first Talkies. As it turned out, these made a fortune for their sponsors, Messrs. Warner Brothers, and by their success established themselves as a new form of entertainment.

A German firm had in the meanwhile, as early as 1919, produced complete designs and given practical demonstrations of a Talking Picture system, and most investigators into the technique of Talking Pictures will admit that they at least found interest in the Triergon patents.

The first man to have any success commercially with sound films, before the recent furore, was Mr. De Forest, the scientist, who gave to the world the amplifier valve, the importance of which has been compared by some with the

AL JOLSON.

[*Courtesy of Warner Bros.*

[*To face page* 25.

A Variable Density Film Record.

[*Courtesy of the Western Electric Co.*

[*To face page* 44.

A Film Showing Variable Area Sound-Track.

[*Courtesy of the Radio Corporation of America.*

[*To face page* 45.

invention of steam. Whether or not so big a claim is justified I cannot say, but Talking Pictures were only one of many branches of scientific development which leapt forward under the magic touch of these tiny glowing bulbs with their enormous powers of amplification and lightning response to feeble and hitherto hardly guessed at impulses of one kind or another.

If *The Jazz Singer* and *The Singing Fool* had failed, it is fairly safe to say that Talkies would have had to wait a few more years before they made their début. As it is they were followed by a wild scramble by every film company for apparatus to make films talk, which has been very successfully exploited by electrical concerns, who had been studying and improving upon Lauste's expired patents, and waiting their opportunity.

The particular system on which *The Singing Fool* and *The Jazz Singer* were recorded was the Vitaphone of the Western Electric Company of America, whereby a 16-inch gramophone record is synchronised with each reel of film.

Close on the heels of Vitaphone came the Fox-Case "Movietone," which photographs the sound record on to the side of the picture. Both Movietone and Vitaphone employ certain devices patented by the Western Electric Company of

America, and any recordings on either of these processes have come to be known as "Western Electric."

Next in the field was the Radio Corporation of America with their Photophone system, which also photographs the sound on the side of the film, but in a different manner from either De Forest or Movietone, in that the latter employ what is known as the variable density system, which to the eye looks like a series of lines of the same length, but varying in intensity from very light grey to deep black. The Radio Corporation of America use a method of recording known as the variable area method, about which I shall have a good deal to say later in comparing it with the variable density method used by British Talking Pictures and the Western Electric Company when they are recording on films instead of gramophone records.

There are many other methods and systems, but they all employ variants of the principles which I have mentioned, and which will be investigated more fully in the following chapter.

CHAPTER II

THE WRITING OF SOUND

It is not intended to pad out this chapter with a lot of scientific figures which can be found in any textbook, and we are lucky in not having to plough through a long rigmarole, or over page after page of diagrams and mathematical formulæ which look like the name of a Welsh town.

The only thing which we have to know a little about is the question of sound, because after all that is what the book is about.

There is no need, however, to be musty about it, or to put on a "cap and gown" air, because, like many things which seem very mysterious, the reasons for them are frequently to be found in our own back garden or lying about in the road. The "unusual" frequently turns out to be the "commonplace" dressed up in a paper cap and standing on its head.

An important point about this film sound-record business is that, whereas it looks as if the manufacturers of gramophone records have reached a stage when they are going to be hard put to it to reproduce very much better records, there seems no reason whatever why the film record

will not make it possible eventually to reproduce sound with perfection and completeness which will surpass the wildest dreams of past workers.

The fact of the matter is that the gramophone-record people are up against a vicious circle of problems; if they get one solved, they find that it is extraordinarily difficult to solve another, so that they have to compromise and do each job as well as they dare without upsetting the others.

The main reasons for this state of affairs are not obscure scientific notions, but perfectly ordinary facts, and are therefore worth considering here.

Sound is caused by something vibrating—it does not matter if it is a telegraph wire humming a tune to itself on a windy day, or the paper cone of a wireless loudspeaker.

As soon as you vibrate something so that it stirs up the surrounding air more than sixteen times a second, you produce a sound.

The slower you vibrate, the lower the note you produce—sixteen vibrations a second will produce those great booming notes from the huge 64-foot pipes of a big organ; they are, in fact, so low that one can almost feel them rather than hear them. The whole question of what sound is has tickled the imagination of scientists for many a century. There have always been inquisitive literal-minded

folk who have spent their lives asking about things which most people take for granted. In times gone by they used to get themselves into serious trouble; you will remember how poor Galileo nearly got himself burned at the stake for having the impudence to suggest that the world went round the sun instead of the other way about. The ecclesiastical "highbrows" of the time bullied him so much that they actually persuaded him to sign a document saying that he had been talking nonsense; but even that did not prevent the old gentleman being distinctly heard to mutter, as he pushed his way out of the hall, "For all that *it does*."

It was Galileo, by the way, who noticed that the longer a pendulum was, the slower would be the period of its swing, which has a parallel in the organ pipes, the slow vibrating low notes being produced by huge pipes 64 feet long, the shrill high notes coming from pipes little larger than a lead pencil.

It boils down to this, that the size of things which are producing sounds has a great deal to do with the pitch of the sound they make, and that things of certain size will always prefer to vibrate at certain notes rather than at others. That is one of the most difficult problems that the

sound-recorder has to face, because it means that unless he is very careful about the dimensions of the various sections of his sound-recording apparatus, he will find that certain notes will be reproduced more loudly, and others more weakly, than they ought; producing, for instance, among other symptoms, the effect of someone speaking through their nose. The early gramophones sounded tinny and horny for at least two reasons, the first being that the reproducing arrangements were frightfully resonant because the dimensions of the various pieces they were composed of made them reproduce some notes too loud and ignore others; the second being that they had very short horns, which made it difficult for the lower notes to emerge at the same strength as the higher ones.

Scientists have shown that if you really want to make a horn that will do justice to the lowest notes, it must be at least 7 or 8 feet long. The problem of getting such a bulky affair into the cabinet of a gramophone has been overcome by curling the horn round itself, the famous "His Master's Voice" Re-entrant horn being the most perfect example.

Every note has its own special speed of vibration, otherwise it would not be that note! Middle C will be produced by anything being vibrated

256 times a second, be it a lamp-post or the string of a fiddle.

An octave above C is exactly twice the number of vibrations, and an octave above that, twice that again. There is no need to go into this point any further, for the purpose of this book, beyond stating that all "notes" are mathematically related. This fact greatly facilitates the scientific design of sound-reproducing apparatus, and enables the engineer to work on a mathematical basis.

It is a great temptation at this point to indulge in an orgy of graphs and other mathematical matters, but we must stick to our bargain and only say just as much as is necessary to make the nature of sound clear. A great deal of work has been done to find out the speeds at which various sounds occur. The things that make speech really understandable are the constant-sounds, F, S, Th, Z, and so on; the speeds of vibration which make these very important sounds are from 1,000 to at least 8,000 vibrations per second. If, therefore, a sound-reproducer is to be actually perfect, it has got to handle a whole range of vibration speeds from at least 20 to 8,000 per second. The extraordinary thing is that there isn't one that does, and there is a good deal of guessing

going on, which we are not aware of when we listen to the average record or wireless loud-speaker. In the same way that it is possible to make out the sense of a telegram, one word of which is missing or wrong, so the ear is able to make an intelligent guess at what a record says even though sometimes the consonants are only hinted at. Indeed, it is possible to reproduce understandable speech on a record which will not handle more than 3,000 vibrations per second.

The ear tells the brain to put in what ought to be there—an extremely clever business.

There will be some who will ask themselves, as they read these words: "If a given note is always the same speed of vibration, how is it possible to tell the difference between, say, the note of a violin and that of a flute?" In point of fact, if you vibrate anything electrically or otherwise, you hardly ever get a pure tone—it always sounds *like* something. You may not recognise what it is like, but it has a distinct character of its own, so that you would recognise it if you heard it again.

To produce a pure *tone* of a certain pitch as opposed to a *note*, the most elaborate precautions have to be taken to see that the only thing present is the actual vibration which gives the pitch you want. You have to get rid of all other odd

sounds. Perhaps I should not say ODD sounds, because they are usually very closely related to the "fundamental" or the pitch we want. The reason why any sound has CHARACTER is that it brings along with it harmonics of itself—a bunch of cousins and aunts as it were. The first harmonic of a note is the fundamental vibration or required pitch multiplied by 2, the second the fundamental multiplied by 3, and so forth. It is the presence of these harmonics to a greater or lesser degree that gives the character to any particular note and enables us to tell, for instance, what instrument is being played, or to recognise a person's voice. The instruments which are richest in these harmonics, especially the first harmonic, are the harp, the piano, and the organ, whose range of vibrations extends from 16 to 9,000 per second.

So we see that if we take the musical scale as extending from about 20 vibrations a second to about 6,000, and then allow for at least one harmonic, we have to account for a range of vibrations of from 20 to at least 10,000 vibrations per second, which even then is not enough to give perfection.

Having got these few facts into our head, we may proceed to find out why it is that the record-makers are having such a stiff time, and why the

film method of sound-recording holds out very high hopes indeed of enabling very much better sound-recording to be achieved, provided that the difficulties which are being encountered at present can be overcome, and there is no sign at present that they will not.

When a record is made the sound causes a sharp cutter to move from side to side as it follows the spiral track on the blank record or "wax" on which the original record is made; a wobbly slot is produced which will in turn cause the needle of the gramophone to go through the movements of the cutter which originally made the groove, so reproducing the original sound.

The records which you buy are not, of course, the actual ones which were cut when the recording was done; they are copies made by a most ingenious process, which is unfortunately far too long to go into now, except to say that the slab of wax which receives the original cutting has a thick coating of metal given it by electrical means, the inner surface of which, of course, carries the reversed impression of the original sound track—a very tricky business.

In early methods of recording, the singer or speaker actually sang into a huge trumpet in the end of which was placed a vibrating surface to

which was attached the groove-cutting apparatus. Now, however, microphones have taken the place of the horn, and the cutter is vibrated by the aid of an electro-magnet controlled by the fluctuating electric currents from the microphone.

Most of us know that if something is stretched across something else—a piece of paper across a box, perhaps—a drum-like effect is produced and a definite note is given out. If the paper is stretched further that note will be higher, or if the paper surface is very much larger and less tightly stretched that note will be lower. These notes are resonances, such as I have mentioned earlier, that is to say, they are the notes which the paper prefers, as it were, to vibrate at most. Practically all structures, be they drums, recording diaphragms, or levers of one sort or another, have at least one resonance, sometimes more than one; and it will, as we have said, be obvious that if a reproducing machine or a recording machine is to deal faithfully with each note in due proportion to the others, resonances must as far as possible be eliminated. That is a very difficult thing to do. The early recording diaphragms with their cutting-knife attachment had to be sensitive and mobile in order to give enough movement direct to the knife, and were, therefore, particularly

phone to resonances. The microphone method has the advantage, among others, that the microphone diaphragm need not be very sensitive because, however minute the electrical currents are, they can be amplified by valve amplifiers until they are sufficiently powerful to work an electrical record-cutter of such massive and rugged construction that it will ignore resonances and other distorting influences, such as the drag of the wax that is being cut, and move only exactly in the way that they are told to move by the microphones hanging in the recording studios.

A particularly pretty method of avoiding a resonance is to accept the fact that there is going to be one whatever steps are taken to prevent it, and to side-track it by arranging that it shall be of such a high pitch that it is far above any note or speed of vibration that can possibly spoil the job in hand. The Western Electric microphones are arranged in this manner, the resonance being put out of harm's way by stretching the diaphragm to such an extent that the resonance occurs at a speed of vibration that is so terrific that it cannot be heard at all!

The Radio Corporation of America do the same thing with their recording mirrors; these are so tuned that their natural resonance is somewhere

in the neighbourhood of 10,000 vibrations per second.

The cutter must of course have a very small point indeed, how small will be gauged by the fact that one "wobble" of the cutter which is recording the vibrations of a note about the top of the piano only occupies a space of about two-thousandths of an inch of the spiral track along which it is travelling! So that not only must the wax be of exceedingly fine texture to offer a smooth enough surface to so minute a movement, but the needles of the gramophones must be correspondingly fine if they are to fit into the track.

It may come as a surprise to my readers to realise that they are imposing a force of nearly two tons to the square inch on the records of their gramophone every time they lower the sound-box on to them to start a tune! That sounds a huge figure, but it is none the less true, and is a very good instance of a very ordinary fact standing on its head and looking ferocious. The pressure on the groove of a record can be truly crushing, and is, in fact, so great that if the point of some cheap or shoddy needles are examined under a microscope they will be found to have been bent over in the form of a hook, which is

ploughing up the record so that it will be ruined in no time. It is tempting to ask how it is possible for a small sound-box, weighing only a few ounces, to exert such a terrific pressure. The point, of course, is that the pressure is *per square inch*, and the point of the needle cannot be more than somewhere in the neighbourhood of six-thousandths of an inch in diameter, otherwise it would not fit into the fine wobbles of the sound track when high notes are being played.

The question arises as to how this gruelling pressure can be reduced; one way would be to make the needle blunter, but that is not possible for the reason that we have just mentioned; another alternative is to speed the record up so that by drawing out the wobbles a blunter needle could be used. If, however, this is done, the public would only get half as much tune for their money as they have done up to the present, and, in addition, would have to be continually changing records unless they were made of a far greater size, similar to the 20-inch used for Talking Pictures records. If, however, an attempt were made to sell records of a larger size than 12-inch, the majority of purchasers would return home only to find that they could not get them on to their machines, and that if they could the motor

would in all probability have difficulty in driving the record round owing to the increased load at the outside of the record.

The needle pressure with the very fine needles which would be necessary for the correct recording of vibrations of over 5,000 vibrations per minute, at the speeds at which the usual gramophone is designed to revolve, is so great that, while it is perfectly possible to make a wax that has a fine enough surface texture to justify the use of such needles, it has not been found practicable to make a saleable record material which combines the desired smoothness of texture and a sufficiently hard surface to withstand the wear of being played many hundreds of times. The disc sound-records are only supplied by some Talkie concerns on the strict understanding that they are not to be used more than a certain number of times.

It is usual with some recording companies to have two recording machines at work when an artist is being recorded, in order that there may be one wax left intact for the factory when the other is "played back" to the artist for his approval. As we should expect, it is the high frequencies that suffer when the "wax" is played back more than two or three times, and in spite of

the most elaborate experimental work this weakening of the higher frequencies may be as much as 50 per cent. of their original strength.

Even if we assume, for argument's sake, that a record material has been produced which has all the points that are desirable, we are still little better off, because a fresh problem arises. It is essential that the needle should fit the groove as exactly as possible, even when the record has become worn after prolonged use, and, paradoxical as the remedy may seem, a small amount of abrasive or grinding material is incorporated in the material of which the record is made, in order actually to grind the needle point to the desired shape. This is one of the reasons why records have a few blank turns at the beginning, in order that the bulk of the grinding-in process may occur before the needle reaches the portion of the track on which the sound is recorded.

There is yet one more little matter with which the record manufacturers have to contend, which imposes yet further limits on the chances of producing a record which can pretend to be anything but a compromise with reality; and while we laugh at the literal minds of the scientists, they have the laugh over the record manufacturers when a problem of the correct recording of

extremes of loudness and softness has to be tackled.

There is the story which has been told about practically every well-known man of science, of the inventor who had a cat to which he was very attached. This little beast liked to be wherever its master was, and, having searched the house until it found him, used to scratch on the door of his laboratory where he was deep in all sorts of complicated mathematical affairs, until he had to leave his work and open the door to let it in. The scientist therefore cut a little hole so that it could squeeze in without disturbing his cogitations. One day the cat committed the indiscretion of having some kittens, so the scientist, being a good scientist, cut another hole a little smaller to let the kittens in as well.

It has been ascertained that the energy necessary to produce a sound that is so loud that it approaches the point when it begins, as it were, to hurt, is well over a million times greater than the energy required to produce one that can only just be heard. While such extremes are not met with in the normal course of recording work, this huge difference of energy, and, therefore, movement of the recording wax-cutter, imposes serious limitations on the correct reproduction of

the variations of loudness and softness met with in orchestral and instrumental work.

Unless the playing-time of a record is to be considerably reduced by only allowing a smaller number of more widely spaced turns of the sound track, there is clearly a limit to the movement of the cutter from side to side. The usual distance allowed between each turn of the spiral track is in the neighbourhood of four-thousandths of an inch, and therefore the cutter may not move more than two-thousandths of an inch on either side of the track, even on the loudest passages, because if it did it would encroach on the turns of track lying adjacent to it.

If, therefore, the movement of the cutter is limited to a movement of two-thousandths of an inch on the loud passages, and if the correct loudness contrast is to be recorded for a very soft passage, the cutter would only have to move one-millionth part of two-thousandths of an inch, which represents a movement of—well, I promised not to drag in a lot of figures, so I had better leave it by saying that if it were possible to make a record of such perfect texture to record so tiny a movement, it would not be able to grind the needle into shape; and if we could make a needle with so fine a point, the pressure on the

record would be so terrific that the needle would either collapse or split the track.

The only thing to do is to see that the sound is kept between limits of loudness and softness, which are not by any means always those dictated by the musical values.

The gramophone record of to-day, however perfect it may sound, is not within many miles of perfection. It is a brilliant series of compromises against the enormous difficulty of making a saleable record:

1. Which will record real notes below those an octave above the bottom of the piano, and up to those vibrations which are just sufficiently rapid to give anything more than a suggestion of the consonants in speech.

2. On which it is possible to give accurate contrasts of loudness and softness.

It is small wonder that recording engineers have turned to light-recording on film as a way out from these problems which they have been trying to compromise with for so long.

It must not be thought, however, that the gramophone record companies are not making progress. The comparatively enormous frequency of 15,000 vibrations a second has actually been "cut" satisfactorily. The problem, of course, is to

get it off the record again for the reasons I have stated, and the added difficulty that at very high frequencies the "wobbles" of the track would become so short that no practical needle would fit them.

Continuous strip recording has the great advantages that the contrasts of volume are not limited by the sound track lying against itself as in the spiral record, and the fact that it is possible to make a continuous record which will play, within reasonable limits, for as long as is necessary, without the necessity of changing anything. A whole play or opera, or even a whole book can be reproduced without interruption of any sort.

A ray of light or an electrical impulse has no physical weight, and where electrical resonances occur they can be dealt with far more expeditiously than their mechanical brethren, even though the electrical equivalents of both weight and inertia exist, both of which have been so brilliantly demonstrated by the "His Master's Voice" experts.

In principle light can be varied in intensity instantaneously in sympathy with the messages from the microphones by suitably arranging the source of illumination so that it throws a pin-

point, or thin slot of light, on to the photographic film.

1. Any variation of the *intensity* of the light will be faithfully recorded on the passing film in streaks of varying "greyness."

2. Any movement of the ray of light, which can be caused to wobble either by a mirror or some other electrical means, will be shown as a zigzag *area* of clear film and densely exposed black film.

The first of these methods is called the "Variable Density" method, and the second the "Variable Area" method.

Lauste, you will remember, mentioned both these ideas. We read in his patent specification:

> We record them [the sound waves] photographically in varying degrees as AREA . . . intensity, and corresponding effects of LIGHT and SHADE.

The photographs show both these methods "on separate parts or in separate positions of . . . the same transparent medium"—so here was the idea of the combined picture and sound-record written down in black and white twenty-three years ago!

We shall see later that the idea of having the sound-record on the same film as the picture

may have disadvantages which, however, Lauste could not possibly have foreseen. One of them is that the sound-record tends to get worn out more quickly than the picture, and the other is a photographic one which I shall also discuss when we go into the troubles of the film producers and the laboratory folk who have to develop the films and make the sensitive emulsions.

There are various methods of causing a fluctuating amount of light to fall on a film for recording by the variable density method. The ideal arrangement would undoubtedly be to secure a lamp which would sympathetically and accurately vary its illumination under the influence of the microphone and which at the same time was *reliable*.

It is true that some lamps are available which will do this, but they have not proved altogether satisfactory. The ordinary filament type of lamp is not suitable for direct light modulation, but lamps of the type familiar to the reader as Osglim lamps, which are used for lighting passages and suchlike places, and which depend for their action on the fact that an electric current will cause certain gases to glow under suitable conditions, have been modified to meet the requirements of Talkie engineers.

The method employed is to start and keep the lamp glowing by applying to it a suitable electrical potential and then to superimpose further electrical fluctuations from a valve amplifier which is controlled by the studio microphones. Unfortunately, however, this type of lamp is not necessarily entirely reliable, and is apt, among other things, to go out—quite apart from the fact that the illumination variation is not always strictly proportional to the strength variations of the microphone impulses except between rather narrow limits, and that its light is generally rather poor.

A further problem to be faced is that, except over a certain range of densities, the response of the light-sensitive emulsions available for sound-recording films are, like the response of the lamps, not always in strict proportion to, in this case, the amount of light falling on to them, except within certain narrow limits; that is to say, at certain strengths of illumination an increase of illumination will not always produce the same increase in density.

Again, unless the illumination is sufficiently powerful, very full "modulation" of the light by the microphone might result in certain kinds of lamp being at times almost extinguished, with

consequent under-exposure of certain portions of the sound track in a desperate attempt to cover the range of sound-contrast required for the artistic reproduction of whatever is being recorded.

One way in which the problem is being attacked is to maintain the glow discharge by means of a subsidiary hot filament, similar to that seen in household bulbs. It seems likely that, while the control of the glow by the direct application of fluctuating potentials from the microphone amplifiers may not prove entirely satisfactory, some such subsidiary glow-maintaining device and another means of controlling it externally will eventually emerge and prove sufficiently adequate to satisfy the exacting standard of such places as the Gramophone Company's magnificent laboratories at Hayes, which, while little known to the millions who use their products, are a household word in the world of science, and from whose test benches and microscopic apparatus emerge those refinements which are the key to public satisfaction and that commercial prosperity with which the company is rewarded for its enterprise.

Academic research is rarely spectacular except to the initiated, but by it and by no other means can perfection be reached. Many of the Talking

Picture magnates of to-day who are relying on empirical experiments and the tolerance of to-day's cinema audiences, will regret in the not too distant future that, in their rush to exploit the public's excited appreciation of the novelty of the Talking Picture, they did not have the enterprise to devote some time, and at least a proportion of the huge funds which have been entrusted to their care, to wringing from reluctant nature that last fraction of efficiency which is the difference between that which will do for the time being and that which will stand the test of time and the ever-growing scrutiny of public discrimination.

There are various methods of externally controlling the amount of light falling on the film. One of these relies on the property of certain liquids to alter their optical characteristics under the influence of electrical potentials, others on various forms of electrically operated shutter devices. These shutters are of various types. If a fine wire is stretched between the poles of a magnet and is supplied with fluctuating electrical impulses it will move slightly from side to side. If this wire is therefore placed before a suitably narrow slit so that when it is at rest it closes that slit, any movement which it makes will allow light

to pass on to the film on which the sound is being recorded. This system has the advantage of allowing a light of any convenient power to be used, and does not reduce the amount of light available for the film to the extent which the electro-optical shutters are apt to do.

The Western Electrical Company, who use the variable density method, make use of a loop of wire to "shutter" the light which is to fall on to the film. One side of this loop passes down between the magnets and the other side passes upwards. The electrical impulses from the microphone pass therefore down one side in one direction and up the other side in the opposite direction, the two sides of the loop moving in opposite directions, at one moment closing together and at the next separating from each other, the light being passed through the space between the two wires as they quiver with the message from the microphones. Only a narrow slit of light reaches the film, and this is obtained by an optical method because, among other things, it would be very difficult to keep a mechanical slit only a thousandth of an inch wide free from dirt and dust. The light is therefore passed through a slit of conveniently large dimensions, and the image of this slit is reduced in size by a

series of lenses until it appears on the film exactly the right size.

The Radio Corporation of America use a similar image of a slit rather than the actual slit itself, but as they use the variable area method of recording, their light arrangements are slightly different. They also employ a wire down which a current is passing placed near a magnet. But while their wire is also arranged in the form of a loop, in the R.C.A. recorder the whole loop tries to twist when a current passes round it. On this loop is mounted a tiny mirror which twitches this way and that, when the vibrating currents from the microphone pass round the loop of wire to which it is attached. A ray of light which is focused on to this mirror is therefore moved backwards and forwards across the slit, making the zigzag margin between the clear and exposed film. The recording range of these commercial light-recorders has until recently been limited to about 7,000 vibrations per second. The "His Master's Voice" engineers have however recently staggered the scientific and motion-picture world by demonstrating a commercial film recorder which will record nearly double the range of vibrations possible before, of 25 to 15,000 vibrations per second!

There is a very great deal to be said for the variable area method of recording; to begin with, there are no delicate graduations of exposure which have to be, as we shall see later, treated with such elaborate care; the record is mainly either black or white. In practice it is claimed that it is possible to handle faithfully a far greater range of modulations than with the other method. In addition to this there is not much risk of under-exposing or over-exposing the film as with the variable density record, because the light is always of the same strength, a point which is of the utmost assistance to the laboratory people who have to develop and print the film.

So much for the actual photography of the sound and the two most important ways of doing it. Now for the reproduction of the recorded sound and the means which are employed to turn the message of the tiny streaks on the film into enough sound to fill a theatre holding two or three thousand people.

We have read about the selenium cell used by Bell and those who followed him, and we know that Lauste used selenium and that Whitson found that it had certain drawbacks. Although selenium has been tried again recently its chief fault is that it fails to reproduce evenly

A Western Electric Photo-Cell.

[*Courtesy of the Western Electric Co.*

[*To face page* 53.

all speeds of vibration, imparting to sounds false characteristics, and among other things giving a husky character to music, which is anything but pleasant.

It is not surprising to learn, therefore, that it is not selenium that the giant 2-ton Talkie projectors obey to-day, but another type of "photo cell," which, instead of merely altering the resistance it offers to an electric current, actually creates one whose strength varies in sympathy with the strength of the light falling on it.

To get the broad idea of how these cells are used in reproducing the sound from the film, we need only turn back to Lauste's specification and substitute a "photo cell" for the selenium which he experimented with and mentions in his specification:

> When such record is made we reproduce it by causing light to pass through that portion of the medium [film] containing the record of the impressions [the picture] and so project them on to the screen SIMULTANEOUSLY causing light to pass through that portion of the medium [film] containing the record of the sound to a cell of selenium [now a photo cell], or other suitable substance by which the varying degrees of light and shade of the record [film] are [re] converted into correspondingly varying electric currents which are . . . converted [transformed] into sound vibrations by a suitable vibrating medium [the loudspeakers].

The photo-electric cells are absolutely instantaneous in responding to the fluctuations of light up to enormous speeds, and are perfectly capable of handling the upper limit of 10,000 vibrations per second which the Talkie engineers are aiming at.

It is interesting to notice how closely allied these photo-electric cells are to the wireless valves of the present day which actually have made their use possible.

It has been known for many years that if certain kinds of light illuminated the plates of certain metals, the spaces round these plates were charged with negative electricity.

In 1883, Edison, in America, and Professor Fleming, who was electrical adviser to the Edison Electric Light Company in London, were puzzling over certain problems in connection with the manufacture of electric-light bulbs. Both inventors noticed that as the carbon filament lamps of that day grew old, their light was greatly diminished by the formation of a dark cloud on the inside of the glass. Some readers may remember this trouble. Edison and Fleming were particularly puzzled by the fact that especially in burnt-out lamps there were patches of comparatively clear glass. A series of experi-

ments showed that these clear portions occurred where the glass had been protected by the intact portion of the filament from the spot where it had actually burnt through, that is, where there had been an excessive amount of heat generated. It was ascertained that when certain metals are heated they, like the metal plates under the influence of light, surround themselves also with a cloud of negative electricity, and that therefore there are at least two ways of causing a metal to release this cloud: (1) by shining a light on to it, (2) by heating it.

The minute electrical impulses from the photo-electric cell, where action depends on the first method, are strengthened by their cousins the amplifier valves, which rely on the second method, in order that they may be used for controlling the loudspeakers in the cinemas.

Let it not be forgotten that it was Mr. Lee de Forest, the inventor of the three-electrode wireless valve, who first showed a practical Talking picture, using sound photographed on to a film.

The photo-electric cell of the Talkie projector is a metal plate on which a light is shining through the film which carries the sound-images. As the film passes between it and the light, so the amount

of the light on the cell varies, and the varying amount of electricity given off is collected and passed on to the amplifiers and loudspeakers behind the screen.

We are in a position now to follow out exactly what does happen both in the cameras in the studios and Talkie projectors in the cinemas. We have seen that there are two methods of recording the sound on the film: the "Variable Area" method, by which the position of the light falling on to the film is altered so that the record takes the form of a zigzag area of dense black and clear celluloid; and the "Variable Density" method by which the strength of the light is varied, the record in this case taking the form of continuously varied grey to dark streaks.

We have gone into the question of what means are employed to produce these results so that we need only concern ourselves with the general functioning of both cameras and projectors.

When recording is being done the sound-record is sometimes photographed directly on the picture film, in the same camera, but usually this is only done in the case of "news reels" when it is not possible to carry round heavy studio apparatus.

When this method is employed this is what happens:

There are, of course, two film magazines on the camera, the top one to hold the unexposed film, and the lower one to hold the film which has been past the lenses. The film passes from the upper magazine down past the picture lenses first, and the picture is photographed on to it; in order to photograph the necessary series of still pictures, the film is held still for a fraction of a second before the next picture is taken; this happens about sixteen times a second for ordinary film work, and about twenty-four times a second when a Talkie is being made.

The film has then to be led to that portion of the camera where the part of it which is going to take the sound-record is to pass before the recording light, which is, of course, controlled by the microphones. It will be obvious that the film cannot be allowed to have a jerky motion as it passes through the sound-camera because if it had the sound would be reproduced in a series of squawks instead of a continuous music or speech. A loop is therefore left between the picture "gate" and that portion of the camera which records the sound, and as the film travels round this loop it gradually loses its jerky motion and passes in front of the recording light smoothly and continuously.

In the case of the work in the studio it is usually found convenient not to have the sound-recording done in the studio itself, and two films are employed, one to receive the picture, the other to record the sound, the sound-recording camera being frequently situated some distance from the studio where it can be fixed firmly down and all possible precautions taken against vibration. The sound does not go straight to the sound-recording camera, but is passed through a special controlling device so that the amount of sound passed on to the film can be adjusted to studio conditions.

The movement of actors about the "set" gave a good deal of trouble when the early and rather insensitive microphone swere first used, and unless there was an engineer watching through a glass window looking on to the studio, the sound would suddenly become faint and the audience in the theatre would not be able to hear what was being said. This controlling work is very difficult to do, and a great deal of skill is required, the controlling or "Monitoring" engineer having not only to see that the sound does not become too soft, but that a sudden shout does not cause the delicate amplifiers to become overloaded and therefore distort the speech or music, whichever the case may be.

When the actors and actresses had to move about a lot several microphones were sometimes employed, concealed about the stage or "set" as it is called, in such positions that there would always be at least one near enough to be the correct distance from the actors as they moved about. When this was done the work of the controlling engineers became increasingly difficult. Not only did they have to watch the amount of sound passing to the recording camera, but they had to see that the microphone nearest the actor who was speaking was switched on and that the others were switched off. They had to follow the actors about with their microphones, switching them on and off as the members of the cast moved about the stage. This was done by means of a "Mixer."

Although there are two schools of thought with regard to the use of multiple microphones, there is, I think, a definite move towards using only one, due to the fact that the modern microphone is perfectly capable of picking up sounds over a large area if it is properly handled.

Separate microphones are still extensively used for "noises off" such as clocks ticking, the sound of the sea, or the noise of traffic. These noises have to be "faded in" through a Mixer at just

the right strength and all the various sounds passed on together to the recording camera.

The reader will be wondering how two separate films are synchronized; there are various methods used, but we need only consider the two main types—the mechanical and the electrical methods.

When mechanical synchronization was employed, the sound- and picture-cameras were coupled together between motor and camera; the two cameras being absolutely linked together so that one could not move without the other. It will be obvious that this method has its disadvantages because it means that two cameras cannot be far apart; and it is not always possible to place the sound-recording camera in a place where it is really protected from interfering noises and vibrations.

The electrical method is being used far more for studio work now, and enables the recording camera to be situated a considerable distance away if necessary. This is how it is done:

Both the sound- and picture-cameras are driven by electric motors, instead of being turned by hand, as they used to be in the days of silent films; these two motors are supplied with electricity from the same special dynamo, and therefore turn at exactly the same speed; if necessary two or

more sound-cameras can be in operation at once.

In a big film studio a difficulty occurs which will not be very obvious except to those engaged on the work; it is this: A number of "shots" are frequently taken of one scene under various conditions; for instance, the lighting may be altered or an actor may miss a word or a line, and it is not always easy to recognize after the lapse of sometimes a month or two what they refer to; the usual practice is to hold up a card with the particulars of the scene written on it before the camera, which then photographs it with the scene it refers to for a few seconds before it is withdrawn and the acting commences; this now has to be done on the sound-film as well, because this is even more difficult to recognize! In fact it is quite impossible, unless the strip of film is run through a sound-projector, which would not even then tell which particular shot it belongs to. The number of the shot used to be telephoned through to the recording engineers, who held up before the sound-camera a similar board so that the details were also photographed alongside the sound-record for a few seconds or even the whole time, so that anyone taking up a strip of sound-film had only to glance at the details

of the shot photographed on to it to know to which bit of the separate picture-film it belonged.

There is a further difficulty; while the picture- and sound-films are in their respective cameras they exactly synchronize, but they have to be taken out for development, and unless special precautions are taken to see that means are provided to enable the engineers to re-synchronize them, it would be practically impossible to do so. However, film camera-men are not beaten by that sort of thing; on each film a series of special dots used to be marked at exactly the same time, so that when the two films were removed to the laboratories for development all that had to be done was to get the marks in a line with each other so that they corresponded. When the sound-films have been developed, much in the same way as an ordinary negative, and printed on to positive film, which corresponds to the printing paper of the amateur photographer, the picture is printed on first, and then the sound-negative is printed on to a strip of the positive film which has been masked while the picture was printed.

A very simple method has been developed in modern film studios for matching up sound-track and picture. It is called the "Clapstick,"

and is the sort of delightfully simple device which experience, and only experience, produces.

When the director is ready, someone jumps in front of the camera and brings two specially constructed boards together with a loud clap. The actual point of impact of the boards is photographed by the picture camera. Instantaneously with this, the sound is registered by the sound camera as a black smudge.

However, we must not delve too deeply into the photographic side of the business at this point because we shall be dealing with that later on.

We know what is required for the sound-reproducing part of the projector—a light sensitive cell and a source of light which is arranged to shine on to the cell through the film. The illustration shows an early arrangement which was made by British Talking Pictures for fitting on to any existing theatre projector.

At the beginning there was undoubtedly a strong case for disc-records, because it then seemed likely that the sound-record on the same film as the picture, which looks such an attractive proposition, may have to be given up eventually for this reason: films get worn and scratched when they have been passed through the theatre

machines a number of times. This does not matter so much as far as the picture portion is concerned; the eye will stand a good deal of wear before the film looks worn and spotted; but the ear is a good deal more fussy, and it seemed that the sound-record would get worn to a point when the "scratch" became irritating to the audience long before the picture was worn out; and it looked as if it might be necessary to have separate sound- and picture-films so that the sound-film could be replaced when necessary, a fresh one being supplied, say, at each theatre at which the film was shown; even with discs certain companies insist on a limit of twenty playings per disc. Fresh records can be sent for any film at very short notice, in addition to the fact that sound-projectors for discs are cheaper than those for films. This method has shown practical disadvantages in that one firm alone has complained that it was having to handle ten tons of discs a week!

CHAPTER THREE

REVOLUTION

A witty American producer was heard to remark once that the noisy studios used for silent pictures were being converted into silent studios for noisy pictures.

The picture-goer, who sits mesmerized by the ghostly screen, little dreams what was going on just off the screen, when the picture he is watching was being shot.

If he could be transported back to the studio while the picture was being made, he would not talk about the silent drama; he would find himself in a bewildering maze of scaffolding, glaring lights and ceaseless hammering and shouting; while under the whirring cameras he would see the Director crouching, megaphone in hand, coaxing, explaining, or perhaps shouting, as the hero raises his loved one's lips to his own, under the merciless lights: "Love 'er, damn you! Love 'er!"; while an electric crane clanks overhead, dangling half a house from its jaws like some huge dog stealing off to bury a stolen bone.

"Lights!" yells the Director, and a dozen electricians heave in their switches with a crash

which nearly splits your ears. "Wind!" he yells again, while a huge wire cage is trundled up behind you and you are nearly blown off your feet as the scream of the wind-fans rises to an unearthly yell.

A sort of devilish Genesis over again.

All that had to stop when the Talkies came, machinery and buildings built after years of experience and at huge expense lay idle, filled only with the echoes of the past and the clamour of the concrete mixers of the builders, who were breaking record after record in the mad rush to make places where films might be made to speak.

Huge notices in the modern studio ask for absolute silence, and stolid commissionaires stand on guard under the red lamps. No one moves, only the actors seem alive, their voices curiously remote and unreal.

Everything had to go by the board—cameras, studios, laboratories, and lights. The new studios are shells within shells. Not even the lintels of the doors may connect the inner and outer walls of these sanctuaries. Their very foundations are in duplicate and rest on vast mats of sand to ensure that not the slightest earth-borne tremor from the outer world shall intrude upon the tranquillity of the "set."

The Talkie producers learnt their lesson when they were desperately trying to adapt their existing studios for sound-work, and have even concluded arrangements with the aviation concerns to have a clear zone of "overhead" when the recording engineers hoist their red balloon, trailing its warning that the electric ear is awake in the shrouded buildings hundreds of feet below.

It is no longer possible to construct a series of "sets" on the same "floor" while "shooting" is in progress; the "set" builders and scenic artists have to do their work while the perspiring actors wipe their streaming faces and make furtive dives for the make-up box, while the camera-men and sound-engineers reload and adjust their apparatus, and the producer consults with his satellites.

The carpenters can no longer nail up their long sheets of three-ply and beaverboard with impunity, for the very materials with which they work are under suspicion.

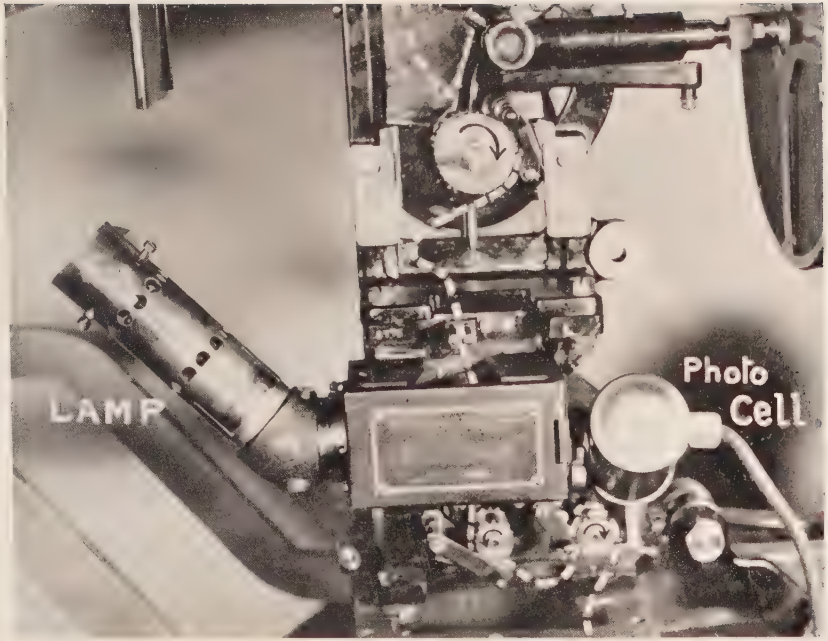
The elegant draperies of the film drawing-room may be as deadly to the recording engineer as a faulty lens would be to his colleague, the camera-man. Every material reflects sound differently, and to different degrees; and elaborate sound rehearsals are being found necessary before the actual

"shooting" begins, to ensure that the sound-camera is not going to be bemused by confusing echoes.

The perfect sound "set" is the open air; once enclose that air with scenery and all the trappings of the world of make-believe and the space between them becomes an arena wherein, unless elaborate precautions are taken, every sound becomes an echoing mockery of itself, and reaches the microphone accompanied by a rabble of jostling sound-reflections and counter-reflections.

"Location" work is not easy at the best of times, and it can be doubly difficult when Talkies are being made. An invention, however, known as the Schüfftan process, has proved immensely useful in avoiding the necessity, either of building enormous "sets" with their attendant acoustic difficulties, or of having to seek "sets" suitable from the acoustic point of view.

This process—a German one—has, however, definitely come to the rescue of Talkie engineers. It is a process of trick photography, which enables at least half of what would otherwise be a very large and expensive set to be built up as a miniature model which is merged into the remaining full size scenery by means of a special mirror.



EARLY B.T.P. PROJECTOR.

[Courtesy of British Talking Pictures, Ltd.

[To face page 63.

MICROPHONES SLUNG OVER A "SET."

[*Courtesy of Warner Bros.*

[*To face page 97.*

THE MODEL.

[*Courtesy of British Schüfftan, Ltd.*

[*To face page* 68.

ONLY THE LOWER HALF OF THIS "SET" WAS FULL SIZE.

[*Courtesy of British Schüfftan, Ltd*

[*To face page* 90).

Part of this mirror is transparent, so that a camera looking at it sees firstly the reflection of the model down to the point where the mirror becomes transparent, and then through it, where the silver backing of the mirror has been rubbed or scraped away, at the full-sized scenery and actors. The full-sized scenery need only be built up to the point where the camera lens sees it meet the reflected model. By calculating the relative distances of the model, the mirror, the camera and the set, the reflection of the model and the set can be brought into exact scale relationship.

The street scenery shown in the illustration opposite is only full size as far as is shown in the next illustration, the rest is the reflection of a small model. The next illustration shows the mirror being scraped away about half-way down the reflection of, in this case, not a model but a transparent photograph of a very large building.

If there is a god of literal-mindedness the microphone is his high priest, so stupid is it that it is incapable of telling anything but the exact and literal truth. It is for this reason that such elaborate and expensive precautions have to be taken in the Talkie studios to prevent the microphone inquisitively listening to four or five sounds at

once. It has to be spoonfed with only those which it is required to record; for it would never do for the melodious tones of an evening paper-seller to intrude in a scene depicting the Great White Silence, if the Talkie Directors are still able to include such a place in their celluloid world of unrealities, much of which, it is to be hoped, the coming of the Talkies will translate to a limbo even more remote, and no less inflammable.

An excellent example of this inability to pick out sounds is furnished if a microphone is placed before a company of artists performing an oratorio or an artist singing with an orchestra.

If a human being turns his back to the stage, he or she is usually able to hear and understand the solo artist with perfect distinctness, in spite of the fact that the orchestra or chorus, whichever the case may be, may, in terms of scientific measurement, be liberating more sound energy than the artist. A microphone placed in the same position would only hear those sounds which are actually loudest.

It is not always easy to arrange, in the Talkies, for the microphone to be near the artist—it must not intrude in the picture. It was for this reason that the movements of the actors in the early Talkies were severely restricted, the usual proce-

A Model Reflected in the Schüfftan Mirror and Part of the Mirror being Scraped Away.

[*Courtesy of British Schüfftan, Ltd.*

[*To face page 70.*

THE FULL SIZE PORTION OF THE "SET."

[Courtesy of British Sch[illegible] Ltd.

dure being to hang the microphone overhead just out of the line of the camera.

There was a tendency in those early years for the artists to speak or sing at the microphone and even look at it occasionally! However, the recording engineers became a good deal more crafty, and it was concealed in all sorts of things from table-lamps to Teddie Bears.

The difficulty of allowing movement by the actors was being overcome by the provision of a number of microphones concealed about the "set" which were switched in and out as the actors moved about. As we have seen, however, the modern microphone enables a great deal of work to be handled by one only.

Anything in the way of echoes or sound-reflections have to be guarded against very carefully, as an abundance of them will only muddle the simple-minded electric ear; it is not at all easy to build "sets" which have correct acoustic conditions.

In the first place the various speeds of vibration comprising the music or speech on the stage are not all affected to an equal degree by the same materials. It is unfortunate that, generally speaking, it is the lower speeds of vibration which are affected least, the high frequencies

which make such an important contribution to distinctness and articulation again suffering loss due to increased absorption over the lower ones.

Even now there is a great deal of compromise going on, but an attempt is usually made to leave the "set" alone, as far as possible, once it has been adjusted for the average conditions under which it is to be used, making any further acoustic corrections by means of overhead sheets of sound-absorbent material.

It is true that there are a number of special sound-absorbent materials available, but it is not possible to paint the majority of them without detracting from their acoustic value, a point which we shall raise again when we come to talk about the theatres in which Talkies, over which so much heart-burning takes place in the studios, have to be shown.

A further difficulty is being experienced by the recording engineers, in that, while it is comparatively easy to "correct" from a sound point of view a given room for a given set of conditions occurring, say, at one end of it, the play may demand that further action of a different character may have to take place in a different part of the same "set."

THE "MIKE" AND THE "STAR." THE AUDIENCE ONLY SEES WHAT IS ENCLOSED IN THE WHITE SQUARE.

[*Courtesy of the Western Electric Co.*

[*To face page 72.*

It might be necessary, for instance, to film a wedding, some scenes being "shot" of the congregation singing with the organ, with a distant view of the fortunate couple, another being considered necessary by the producer of a pair of 10-foot lips murmuring "I will" on the altar steps, with the congregation in the distance this time.

The acoustic conditions for the two such "shots" can be entirely different, and, although the scene may look the same, means have to be devised to make the necessary acoustic alterations in such a way that these will not be spotted by the camera.

There is actually an echo in every average living-room, which may be quite unnoticed by ears accustomed to the normal conditions of a dwelling-house; if, however, a microphone is placed in such a room, any sounds heard through it will be accompanied by an astonishing amount of echo, which may be seriously disturbing to intelligibility and quality of reproduction.

It is suggested that the reason why we are not normally conscious of this echo is due to the fact that we are using two ears. If a sharp rap is made in a room first with both ears free and then with one blocked, the presence of this echo is

frequently quite noticeable together with a marked change of tone.

Not only is the microphone stupid, but it is "*mon*aural," so that any recording done on a microphone circuit is, therefore, not heard by the microphone as we hear it.

Generally speaking it has been found desirable to allow as much natural reverberation as the microphone will permit, in order that the actors may be given conditions as nearly approaching the normal as possible. It is as difficult to make an impassioned oration with one's head under the blankets as it is glorious to sing in a bath.

It seemed at one time that it would be desirable that the Talkie actor should retain the declamatory tones necessary on the legitimate stage, but again the modern microphone enables him to talk in a far more natural and restrained way without the necessity of the operators having to increase their valve magnification, introducing the "boomy," unnatural tones which such amplification has by experience been shown to produce.

The sound-engineer has had to develop an ear for his work and has to shift and shuffle his draperies as the camera-man swings his banks of lights and peers through the various sights of his

cameras; the sound-engineer has to consider, too, what the acoustic conditions of the theatres are likely to be in which his work is going to be projected, and he has to adjust the conditions of *his* "set" to produce a record which, when reproduced, will compensate for them.

The passing of an actor from one room to another is not such a simple affair as the finished film would lead us to imagine; to begin with the filming of the room which is entered may take place many weeks after the scene where the actor is seen, perhaps, lighting a cigarette, opening the door, and passing through it. It is on occasions like this that the "Floor Secretary," that lynx-eyed and highly efficient functionary, has to keep his or her wits about them.

It is not at all easy to remember exactly what you were wearing six weeks, or even days, previously. When the time comes to film the other side of the door, it would never do for our hero to appear with a cigarette which has become miraculously reduced to a "tab end," and an entirely different collar and tie. The Floor Secretary may dash across to him when he appears from his dressing-room, and look him over from head to foot, notebook in hand. "Mr. Snooks, your hair is parted half an inch too far down,

and you ought to have three pencils in your waistcoat pocket instead of a fountain pen," she will say.

Even Floor Secretaries are not perfect. Not so very long ago a film was shown in London where the heroine was seen in a drenching rain-storm with an immaculate marcelle wave and bone-dry clothes after she had been severely handled in the previous scene only half a mile down the road.

It is difficult to know where the Floor Secretary's job ends and where it begins. Not so long ago the Floor Secretary on a particular film which was being "shot" in the open air with a crowd of negro Extras, who had been collected out of the local docks, noticed that these coloured gentlemen were looking distinctly morose, when it was most important that they should display that light-hearted gaiety which the prospect of a succulent steak of stewed missionary would normally give them. Over went the Secretary to inquire the cause of such sullen glares and mutterings. Was it the pay that was worrying them? No? Was it that they were cold? No? Well, what was it? The spectators were calling them monkeys! Shame!

Off she went to the Director, who settled the

trouble by taking the arms of two of the coloured men and making an impassioned speech to the crowd, which produced three cheers all round for everybody concerned.

The Floor Secretaries now have their counterpart among the recording engineers, who must ensure that the acoustic conditions of "sets" which are used consecutively in the film have, as nearly as possible, the same sound characteristics; it would not do for a character to stride from one room to another and speak with an entirely different voice! On the other hand, such differences of acoustic condition can be made use of with considerable effect.

The broadcasters were quick to see the possibilities of manipulating echo, more accurately termed reverberation, handicapped as they were to show change of location. In life these subtle changes of sound are noticed only subconsciously, and rank but of secondary importance, aided as we are with our eyes. We do not notice consciously, for instance, that when we speak in a well-furnished room there is no noticeable echo, but that if we betake ourselves into the hall there is a considerably increased echo, while when we have emerged through the front door into the road there is practically no echo at all.

While it is not so imperative in the Talkies to make the most of every sound-suggestion possible to assist the brain to construct missing optical impressions, which we have by the custom of life become accustomed to expect, a great deal of sub-conscious sound-suggestion work can be and is being applied to Talkie technique.

Simple examples serve to show the value of noises which can greatly enrich the scene before our eyes; the popping of a cork has, from time immemorial, suggested conviviality, and the relentlessness of time mocks us in the ticking of a clock. But it must not be the wrong kind of clock! Especially where sounds are concerned, it is better to leave things undone rather than introduce a jarring note, and subconscious appeal should, like good manners, only become obvious when it is not present. The fretful pathos of a millionaire sitting in his office waiting for the turn of the Stock Exchange to bring him news of fortune or failure should not be emphasized by the wooden voice of a kitchen timepiece; the velvet tones of a Westminster Chime would, however, serve not only to mark the passing of the fatal minutes, but to introduce a telling hint of luxury withered by anxiety.

In the majority of cases the most apt and

spontaneous sounds introduced into pictures are the result of a great deal of anything but spontaneous experiment. Separate microphones are frequently used, and the fateful ticking which marks the agony of a riven soul may, as likely as not, proceed, not from the clock which is so faithfully featured in the scene, but from another held up to a microphone slung up in some convenient corner of the studio by a perspiring electrician, and "mixed" into the sound-record by the monitoring engineers at exactly the moment when the producer thinks that it will be heard with most effect.

The noise of "smashes" of any kind are most complicated sound structures, and a far wider range of vibration speed response is needed to record the impact of a railway collision than the whole musical range of a church organ. Sudden sounds, such as the report of a pistol, have long been a problem to recording engineers, because such sudden surges of energy may build up and die away so quickly that the electrical components of the recording gear may, as it were, become momentarily puzzled, and fail to respond in a normal fashion. In the case of sounds which have to be reproduced artificially because of studio limitations, noises have to be devised which,

when they have been distorted by the recording gear, will resemble the sound that it is required to convey. The rapping of a cane will often give a representation of rifle-fire, while an actual shot would only reach the ears of the audience as a dull thud.

Sea waves can be simulated almost exactly by the gentle rolling of small shot over the surface of a drum, but actual waves are heard only as a mixture of rustling and sizzling, entirely unconvincing as compared to the artificial product. It is quite impossible to reproduce effectually all the noises of a busy street, because of the indiscriminating nature of the microphone; and the sound-effect expert will not, if he is wise, attempt to do so, for the ear tends to pick out only those component sounds to which it is particularly sensitive, either by reason of mood or association.

The best that can be done is to study the psychology of the position carefully, and select one or two simple sounds which are highly characteristic of the situation, inserting these to the best effect. A microphone hung in a street would render only a confused babble of noises, which would by themselves be far less effective than if such characteristic sounds as the "ting" of

a bus bell, or the voice of a boy calling papers, were inserted into the babble to rouse the required associations in the spectators' mind.

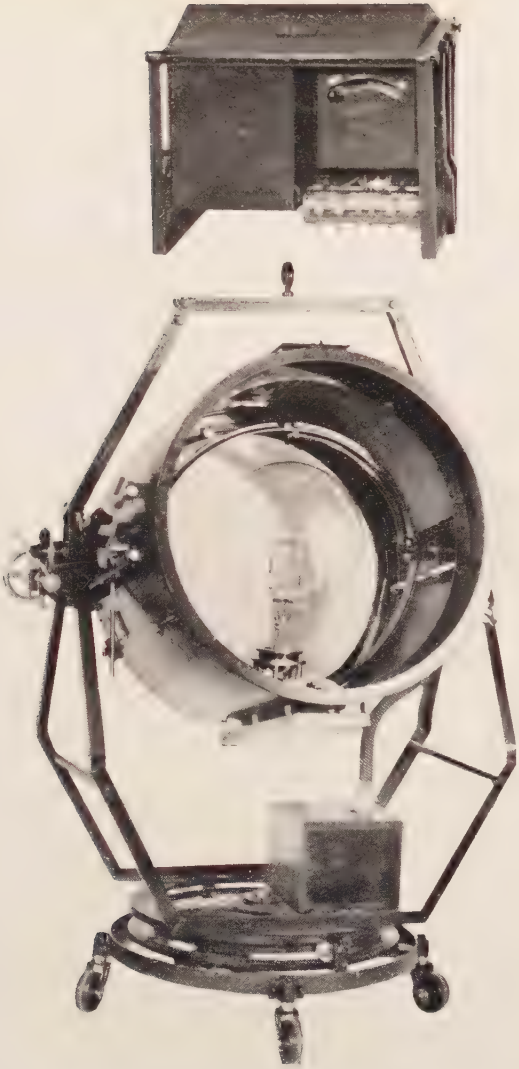
Sounds that are characteristic of a situation must be carefully chosen, and they must be those that could not mean anything but one thing and one thing only; an excellent example of which is that of a railway engine running "light," whose peculiar care-free "clank" rouses a world of associations in the mind. On the other hand, the starting of a train has to be carefully analysed into its component noises, and they have to be produced individually and combined correctly. The hiss of the safety valve, the thud of the pistons, the swish of each puff of steam, and the groan of the train have to be made separately and performed together. The bursting of a shell has to be produced with at least five different noises made on five different devices.

There is no need to enumerate any more examples except perhaps one. The curious "pickling" noise caused by the gentle lapping of water against the side of a small boat, and highly suggestive of drowsy river evenings, can be reproduced through a microphone with an exactness that is uncanny, by rattling a few matches in their box between the forefinger and thumb.

The sizzling arc-lamps of the pre-Talkie days had at first to be remorselessly scrapped as being far too noisy with their ceaseless clatter and hissing; they were replaced by enormous incandescent globes, some of which consume as much as six horse-power of electricity each, while frames of smaller lamps containing as many as seventy bulbs at a time are being made and used.

Some idea of the size of these great lamps may be gauged by the fact that the stands on which they are mounted are being fitted with compressed air brakes to enable them to be moved quickly and easily without damaging their filaments, which are nearly as thick as a pencil lead, and reach a terrific temperature many times that required to melt a bar of steel! The glass bulbs are as much as twelve inches in diameter, and woe betide any absent-minded person who stands too close to these miniature suns for too long, for he will soon wonder where the smell of burning is coming from, until he puts his hand up the back of his head and finds that it is his own hair that is being singed.

When the arrival of the Talkies demanded the development of larger and larger lamps, or "Inkies," as they are called in the picturesque



A 10,000-WATT "INKY."

[*Courtesy of the General Electric Co., Ltd., London.*

[*To face page 82.*

slang of the studios; the lamp manufacturers very soon found that they were limited in the size of the lamps that they could make, because of the trouble they experienced over the bulbs becoming blackened in much the same way that the early household-lamps used to deteriorate.

The problem of overcoming this difficulty with such enormous lamps was not an easy one, and a whole series of experiments were started again, this time by the electrical engineers, to see why this bogey, which they thought had been cured years ago in the smaller lamps, had reared up its head again.

The Americans tackled the idea with characteristic promptness in a most ingenious way; they arranged that a small amount of abrasive powder should be left inside the globe, so that when the inside of the bulb began to show signs of blackening, all that was necessary was to spin the bulb round, thereby whirling the powder round the inside of the glass, so scraping away the dark material, which then fell into the bottom of the globe out of harm's way.

The English engineers, however, went one better, and have actually succeeded in making a bulb which will not blacken at all, working on the lines that prevention is better than cure. The

General Electric Company of England is rapidly attaining a world-wide reputation for their "Inkies," and their installations are being sent to all parts of the globe.

American engineers are frequent visitors to these shores to study our methods of sound-studio lighting. The General Electric Company's laboratory experts made the highly important discovery that the filament was not alone responsible for the trouble.

Tungsten is used for the filaments of these lamps because it can be raised to a very high temperature before it starts to evaporate, but the fact that the metal which was used in the manufacture of the small wire supports which are to be seen in any electric lamp, and are there to prevent the filament from sagging, would start to evaporate at a very much lower temperature, had not previously had a sufficiently serious effect in the smaller lamps to warrant further research. The enormous heat of these new monsters which the Talkie camera-men demanded very soon showed that the whole question of high-power lamp design had to be gone into far more deeply than previous commercial conditions had demanded. The material of which the filament supports used to be made has been modified,

3,000-Watt Incandescent Studio Lamp.

[*Courtesy of the General Electric Co., London.*

[*To face page* 84.

A Bank of "Inkies."

[*Courtesy of the General Electric Co., London.*

[*To face page* 85

with the result that British "Inkies" are in universal demand.

This state of affairs is as gratifying as it is curious, because in the past, when the film business offered enormous markets for arc-lamp equipment, the British electrical firms allowed them to slip out of their hands, and the American and German equipment became standardized to such an extent that practically no trade was done by British Electrical firms with film producers abroad. The German lamps were especially famous, and it is difficult to explain why they have allowed themselves to drop behind in this new development.

The Germans are indeed only just beginning to get going with Talkies, and were until recently using arc-lamps, housed, as the early American Talkie people enclosed their arcs before they could get large enough "Inkies," in "glorified greenhouses," to shut out the sound of the spluttering carbons.

The illustration of one of these huge lamps gives an idea of their size, and some of them use enough current to run a fair-sized broadcasting station. The current they require is so enormous that any attempt to switch on a lamp of the kind that we have been describing, as one should

switch on a household bulb, would result in an explosion which would blow the bulb into "smithereens" and plunge the studio into darkness. The current must be fed to the lamps slowly and gradually, and a complicated starting mechanism has to accompany each lamp. The largest lamps actually have their own ventilating apparatus, which has to be at work continuously drawing the heat away, lest they should melt with their own heat. The cooling fans are electrically driven, and the lighting engineers have another problem in designing a cooling-fan motor which will not cause interference with the sound-recording apparatus when the lamps are used for close-ups, and the microphones are cheek by jowl with them—and so it goes on!

Many of these lamps are nearly a thousand times more powerful than any bulb that the reader is likely to have in his house, and he can readily realize what a terrific job the film electricians have nowadays. Imagine one bulb requires nearly 15 horse-power of electricity to light it!

A load of 22,000 amperes at 115 volts and nearly 4,000 of these great lamps were used for one scene only, when "Broadway" was being filmed—enough electricity to drive four express trains at full speed used in lights alone.

Readers who have valve radio sets may have noticed how the turning on of a light switch or the ringing of a sometimes quite distant front door bell will cause a rattle in their ear-phones or loudspeaker. As soon as the film people started to put their microphones in the studios, they very soon found out that the electric wiring and switchboards which had served them so well in the past were a constant source of nuisance. Every nut and bolt had to be overhauled and miles of wire had to be ripped up and replaced with new material to prevent the possibility of an exasperating hunt round the studios to find the cause of some hiss or crackle picked up by the microphone circuits, and recorded on to the film sound-record as an unwanted accompaniment to the words or music.

It is interesting to remember that, to whatever pitch of perfection these huge incandescent lamps, 60 per cent. of whose light is red, had been developed, they would have been practically useless had there not been in existence Panchromatic film, which gives such superior photographic values, due to its increased sensitivity to the red component rays of light, making it once again possible to make normal exposures. Ordinary film reproduces red as black, no matter

what shade of red it is; panchromatic, however, registers these differences correctly.

Panchromatic (all colour) plates were only just beginning to be used when the war broke out, and their red sensitive properties were found extremely useful when making photos of the ground from aircraft in misty or foggy weather. The fog-penetrating properties of the yellow and red rays are well known to motorists, and the use of panchromatic plates, which could make use of these components of light, enabled our aerial observers to get clear photographs of the ground when it was, as far as the eye was concerned, veiled by mist.

The Inkies have not entered the motion-picture field without some outcry, and in Austria the Sasha Film Producing Company are using a combination of arcs and inkies in their sound-studios, which are the largest in Europe.

Progress is being rapidly made in readapting the arc-lamp to the new conditions of the sound-studio. A lamp has recently been produced by a British firm which it is claimed is absolutely silent, while in America the problem has been attacked with an electrical smoothing device christened by the American film engineers with that genius for picturesque slang—a "Whistle-box." Inkies

AN EARLY CAMERA "BOOTH."

Courtesy of Warner Bros.

[*To face page 89.*

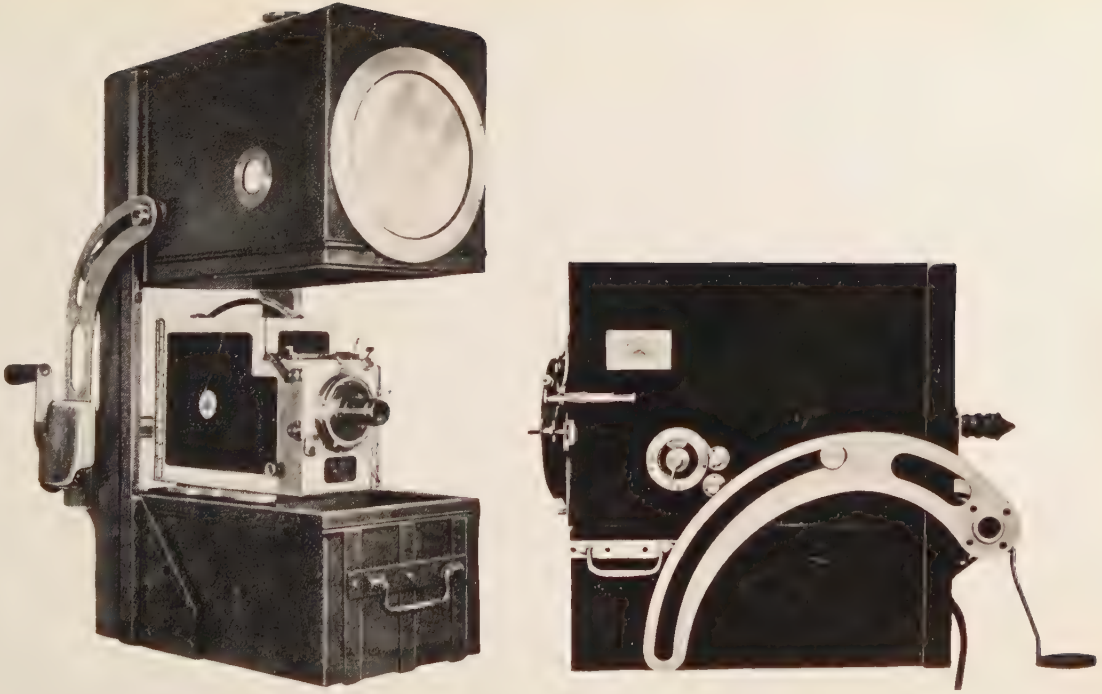
are by no means universally liked by the cameramen, who have always to remember that the projectors in the small country theatres are apt to be of the "weird and wonderful" variety, and they have to adjust their ideas of what the lighting of their "shots" shall be with this in mind. Some are, for this reason, reluctant to pledge their faith in incandescent lighting, because they maintain that the Inkies do not give sufficiently sharp detail on dark subjects to withstand the motley array of more or less inefficient projectors in the smaller cinemas.

When the first Talkies were being made, one of the first things that bothered producers was the noise of the cameras, especially where more than one camera was being used at once. Studio cameras were often a good deal noisier than a sewing machine, and it is indeed a very difficult matter to make a machine running at such a high speed in any way sufficiently silent for Talkie work. Everything had been sacrificed to smooth and rapid action, and silence was the last thing that the manufacturers had bothered about.

The obvious course was adopted when the early Talkies were being made, and the cameras and their operators were enclosed in soundproof boxes or booths, much to the camera-

men's disgust. These booths cramped their range of action badly, and prevented the swing and "Pan" (panorama) "shots" beloved of that fraternity. The camera was pointed through a special window made of very thick optically-worked glass. The dimensions of these windows have had to be very carefully worked out, and their width and thickness have had to be the subject of very careful experiment, otherwise they started to vibrate on certain sounds and produced a buzz which, while frequently quite inaudible to the ear, was recorded faithfully by the sound-camera. A good many feet of film and hours of expensive time were wasted before the source of these mysterious sounds was traced. These windows had to be at least a quarter of an inch thick, and, stuffy as the draped and curtained studios were, they were cool compared with the sweltering heat of the camera booths.

Although the most elaborate booths were built, some of them holding a crew of as many as ten men, and mounted on power-driven trollies, they were clearly not the real solution to the problem, and were at the best a makeshift, until camera manufacturers had succeeded in rushing through a type of camera which was silent enough in



DEBRIE CAMERA BLIMP.

[Courtesy of Visual Delivery, London
To face page 94.

action to do away with the necessity of such cumbersome and cramping devices.

Camera-men, like other men, have their feelings; no one who has heard it can forget the immortal story of the camera-man who, while perched on a roof to film the funeral of the late King Edward, was detected spasmodically turning his camera in time to the Dead March with tears pouring down his face! His film was not a success!

The latest device for silencing cameras has been dubbed the "Blimp," and is in effect a sound-proof camera-case completely enclosing the camera but allowing access to the controls. The two illustrations show a "Debrie" camera "Blimp" both open and closed.

The work of the camera manufacturers was further complicated by the fact that for sound-work it was found to be necessary to work at a speed of twenty-four pictures to the second instead of sixteen, which had been usual for silent picture work; two reasons, among others, for this was that the sound-track requires a greater length of film per second for satisfactory recording, and secondly, should it be necessary to mend a broken film, the fact that the sound-track is more spread out

renders the omission of a small section less noticeable.

A series of experiments was at once started to trace every possible cause of noise, and some very unexpected sources were found. It was, for instance, ascertained after a series of laborious tests that a peculiar drumming or booming sound was caused by the vibration of the metal film-magazines. This trouble was stopped by the provision of a spongy rubber cover and by fitting baffle-plates, very similar to those in the silencers of motor-cars, which were in turn covered with sound-absorbing material, and drilled with a series of spiral holes. Ball bearings were, until recently, extensively used for cameras, but they were found to be a very troublesome source of noise, and had, when necessary, to be ruthlessly scrapped and replaced with plain bearings, the proper lubrication of which necessitated a further series of experiments, because it is of the utmost importance that while they should be adequately lubricated, no oil should be allowed to get on to the film, for it should be remembered that a coloured stain, while appearing quite transparent to the eye, may seriously offend the dilettante photo-cell.

A good deal of trouble was found to lie in the

use of metal cog-wheels, and these have been now replaced with gear-wheels ingeniously moulded at high pressure out of non-metallic substances, such as paper and the black and brown material familiar to most of us made up into knobs for tuning radio sets.

For various reasons, which we need not go into now, spring belts have in the past been used to connect the rotating film-magazines to the shutter mechanism. These were found to be a fruitful source of noise, and have been replaced, in the newly designed Talkie cameras, with belts of linen and other materials held at the right tension by an ingenious arrangement of spring pulleys, so that they are allowed enough stretch to take up any fluctuations in the tension of the film as it passes from one magazine to the other over the toothed rollers or sprockets which feed it past the shutters and lenses.

These sprockets gave trouble in rather an unexpected way; it was found that a considerable amount of noise was caused by the teeth on them as they engaged with the perforations cut in the film; this trouble was, of course, aggravated by the fact that the cameras were being run faster than the speed that they were designed for. By dint of reducing the speed and range of move-

ment of every possible moving part, a further improvement was effected.

In some cases even the shutters themselves have been covered with a layer of sound-reducing felt.

The modern Talkie camera is a marvel of high speed, research and ingenuity, and can be used, it is claimed, within ten feet of a microphone, which would not have tolerated what was an up-to-date camera, only a few months ago, 100 feet away.

When the first silent cameras were rushed through the works, it had not been possible to make one which could be reversed, enabling the exposed film to be wound back on to the upper magazine again and re-exposed, so that the fade-in and mixing shots, where one scene fades into the other, could be made; but even that has been achieved now, and the camera-men are happy again.

Talking of non-reversible cameras in the early days of Talkies is reminiscent of an amusing story told by Roy Pomeroy, the brilliant English Producer and Film Technician, who produced the first All-Talking Film *Interference*. One of his studio cameras was driven by an electric motor. During a critical moment of the work, the motor

decided to change its mind, and started to revolve the other way round.

As Mr. Pomeroy said: "The camera was not designed to reverse, and what was left of the internal mechanism when the motor had finished with it was not much further use for motion-picture work!" An up-to-date Talkie camera can cost anything up to £2,000.

Readers who are interested in photography will realize that the introduction of the photographic sound-track on to the same film as the picture has meant the development of an entirely new dark-room technique, the whole process of film printing and development being further complicated by the fact that experience tends to show that the contrast unit or "Gamma" of the sound-track should be considerably lower than that which is considered desirable for the picture portion of the film. In other words the sound-track, especially when it is of the variable density type (such as the De Forest system used by British Talking Pictures and the American Movietone), should be softer in tone gradation than the contrasting black and white of the picture portion.

In the old days the exposed negative film was wound on wooden racks, very much like the

frames of a clothes-horse, these racks being then immersed in large upright tanks of developer. They were periodically raised, so that the man who was responsible for their treatment could see how they were getting on; when he considered them finished, they were rinsed and put in the fixing tank. This process naturally demanded a very high degree of skill, and the "developer," as he was called, held a very important position. On his shoulders rested the responsibility of the whole of the production costs, for should anything go amiss with his end of the production, parts anyhow of the film would have to be re-shot on the studio floor, or on location, as the case might be, with consequent additional delay and expense.

With the advent of the sound-picture this rack and tank method had to be dropped; highly skilled though the "developer" may be, he is yet human and cannot attain the machine-like precision which the proper treatment of sound-tracks demands.

Machines for the automatic treatment of positive films, originally evolved in England, have been in use for some years; and machines for the treatment of negative films have recently been devised which will do the work of the "Developer," whose

responsibility is still as great as before, but the risk of trouble has been reduced to a minimum.

The importance of this will be obvious when it is realized that, whereas it is a comparatively easy matter to run off a fresh print from the negative, any accident which befalls the negative itself means a re-shoot of the portion of the production affected.

British inventors not only produced the first film moving pictures, Will Barker and Mr. Hepworth, whose original automatic film developing plant was in regular use in 1916, were in the field in Britain with this invention three or four years before cinema-men anywhere else.

Hepworth's machine automatically conveyed the positive film, on to which the picture had been printed from the camera negative, through the processes of developing, fixing, washing, and drying. A number of these machines gave good service in his Walton laboratories for years.

Like others, these inventors had to face a good deal of ignorant prejudice from the old-time "Developers" with their secret formulæ and private systems. They were reluctant to surrender their craft to what they feared would be an inflexible and unimaginative automaton. They have, however, learnt better now, and to-day

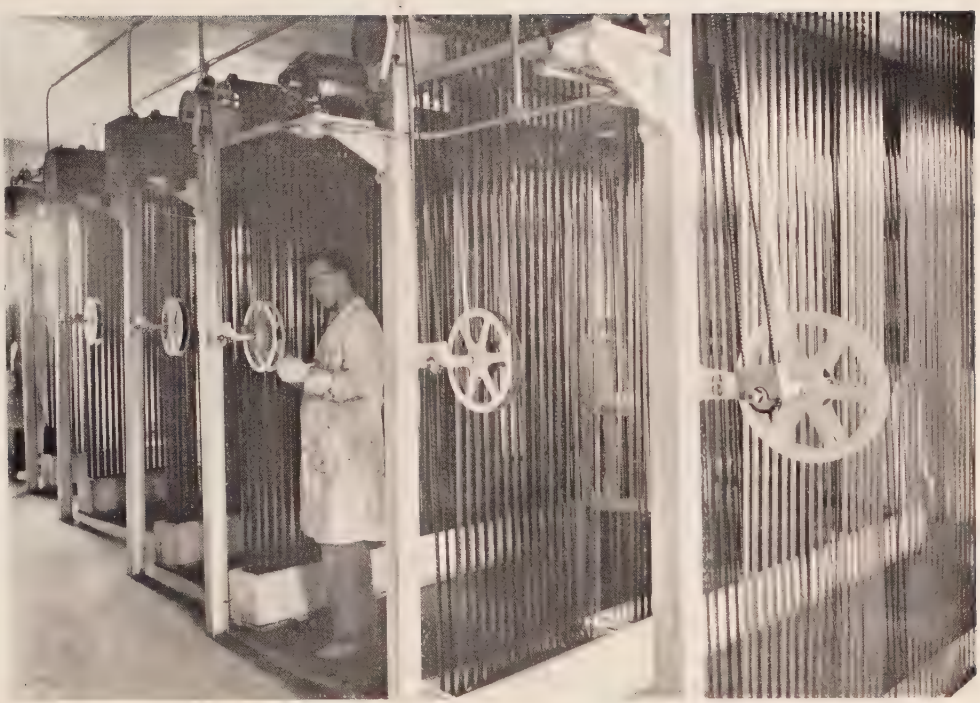
over 80,000,000 feet of film, or roughly 16,000 miles, are "processed" yearly in the London area alone.

The Developers and laboratory Managers need not have worried; their responsibility is as great as ever it was; there is still the same need for the special treatment of various scenes, and the old hands have had the scope of their experience greatly extended by the methodical progress of the film as it advances picture by picture from one electrically driven roller to another, untouched by hand and under automatically controlled atmospheric conditions.

The Vinton plant is representative of one of the earliest automatics and is widely used to-day. There are more Vinton machines in use in this country than any other make.

The fact that Talkie sound-track negative is actually being satisfactorily treated on one of these machines, which were originally designed for positives, at the present time, is a tribute to their designer.

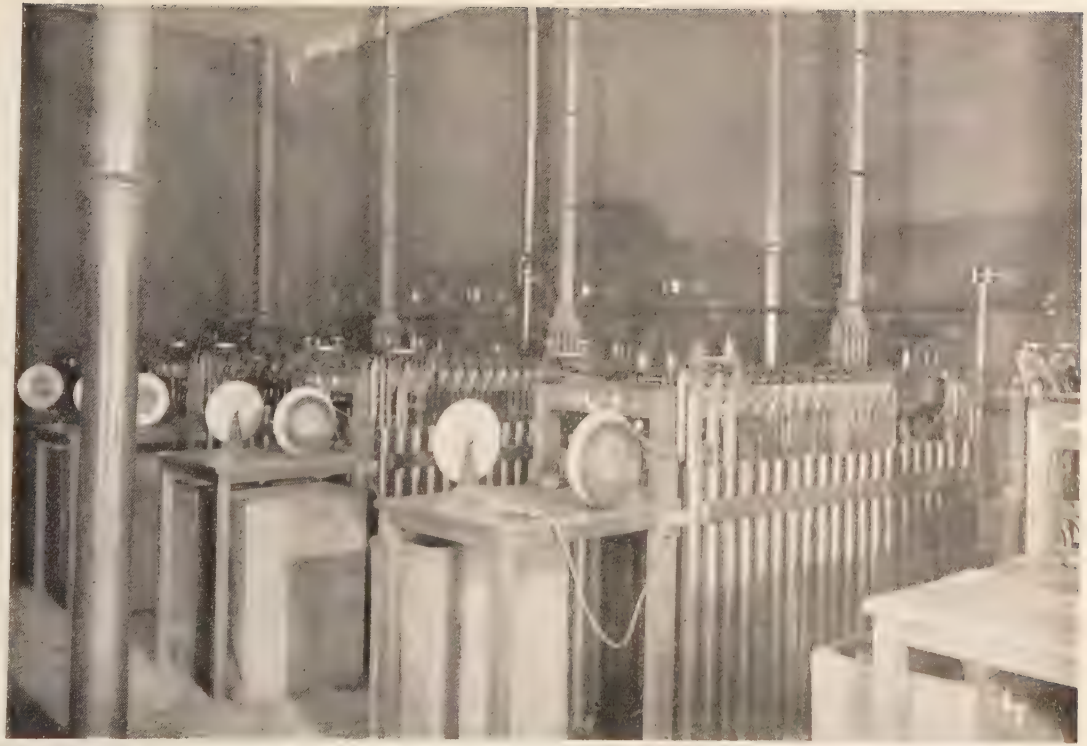
The film is fed over the first toothed roller or "sprocket" down into the first tank of developer, where the loop of film is held down in the developer by a flanged roller weight. It is passed through the developer several times, the



THE DRYING ROOM OF THE "VINTEN" AUTOMATIC DEVELOPING PLANT.

[*Courtesy of W. Vinten, Esq.*

[*To face page 98.*



THE LAWLEY AUTOMATIC DEVELOPMENT PLANT.

amount of development being controlled by the speed at which the sprockets are allowed to revolve. From the developer the film travels, by means of further sprockets, into rinsing tanks containing water to remove any traces of developer from it before it is passed into the tanks containing the fixing solutions. After being fixed, the film is washed again and passed into the drying-room, where the air is maintained at a suitable temperature and humidity by automatic controls.

Mr. Vinton does not believe in drying-cupboards or enclosing the film in enclosed spaces; he attacks the problem from the other end, and provides special apparatus which ensures that the film encounters nothing but clean air.

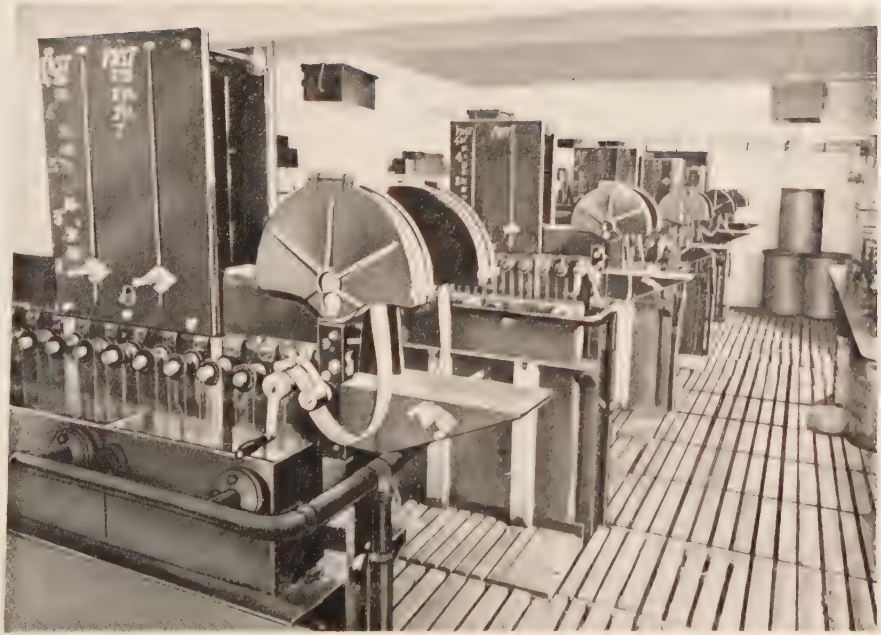
Another British plant, the Lawley, differs from other automatic plants, inasmuch as it employs a series of long ebonite tubes, instead of tanks or vats, as containers for the various solutions. These tubes, some twenty feet deep, are arranged in a row with a sprocket over each tube. These sprockets are all mounted on the same shaft, but each sprocket is fitted with an extremely ingenious little adjustable clutch by means of which the speed of each may be separately adjusted.

The method of controlling the amount of development that any particular strip of film

requires is particularly neat. After the film has emerged from the first tube, the operator is able, by inspecting the first traces of image that has appeared on the negative, to decide how much further development is required; this he adjusts, by arranging that the loop of film in the subsequent tubes shall be of a certain length; if a greater amount of development is called for, the loop is allowed to extend right down the tube, if less development, the loop is shortened, so that the film spends less time in each tube.

Not only is the developer weakened by the chemical process of developing the film, but the film itself, being dry when it enters the tubes, soaks up a large quantity of developer, much after the manner of a sponge: this has to be made up in each tube by supplies of fresh developer, which are squirted in continuously under pressure through a series of tiny holes extending down each tube.

The 1,000-foot roll of film passes in and out of each tube in turn; the first three tubes being usually developer, the fourth water for rinsing, the fifth and sixth hypo, followed by several tubes for the final washing. After the developed and fixed film emerges from the last washing tube, it passes through an extremely ingenious suction



THE DEBRIE AUTOMATIC DEVELOPING PLANT.

Courtesy of Aveuve Debrie.

device, which removes all superfluous moisture, and prevents any water being taken into the drying tubes. Here it is dried at a constant temperature and is passed out to be wound on spools ready for use. Further tubes are provided with various colouring solutions, if it is required to tint the film.

The film does not need the usual polishing to remove any streaks of dried solution from the celluloid side, because the suction device has already removed the superfluous moisture, and the film emerges from the final drying tube polished.

Debrie, the famous French firm of photographic apparatus manufacturers, whose camera "Blimp" I have already mentioned, have evolved a machine which is extraordinarily compact. One unit, capable of handling well over three thousand feet of film per hour, occupies a space only twenty feet long by two feet wide.

In the Debrie machine, the speed of the film is kept constant, but provision is made for variable development by altering the depth to which the film is allowed to enter the tanks.

Superfluous moisture is, in this case, blown away by compressed air.

Most of the developing plants in America

follow fairly closely the idea of the Vinton machine, but they differ in one important point; the film is never allowed out of the solutions. All shafts and sprockets revolve actually in the liquids. It is a moot point whether taking the film out of a bath into the open air and then into another bath again has any harmful effect upon development; but a certain school of laboratory experts maintain that it has.

The reason why, in the Vinton system, the film is allowed out of the bath, is so that absolute control may be in the hands of the operator, inasmuch as he can see a double length of film over each sprocket, and can watch the whole length of film as it passes.

Since, in the American systems, the film cannot be seen in the baths, arrangements are made whereby about a foot of film is allowed to emerge at a time, and is passed over a small piece of glass about six inches long, under which is placed a special optical lamp, suitable for the type of film which is being treated. The film then re-enters the tanks and is not seen again until it emerges fixed and washed.

We have seen that the machine method of developing films offers tremendous advantages over the old-time hand-worked methods, because,

in addition to the more regular development it gives, it is possible to treat such huge lengths of film at such an enormous speed.

The coming of the sound-track, however, made it absolutely essential that machines should be used for various reasons.

Absolute regularity of development is highly important for the sound-track, and the old methods were not by any means blameless in this respect. One of the troubles of developing sound-track by the rack and tank methods was that, unless the developer was kept in perfectly regular motion, the solution tended to become weakened by the denser streaks on the track, which took more out of the solution, and this weakened developer consequently under-developed the adjacent more lightly exposed portions of the emulsion. This gave rise to incorrect contrasts in the track.

The great enemy of sound-track is the danger of stains on the film. Stains, which may not be visible to the eye at all, may have the effect of almost entirely cutting off the useful rays of light from the sensitive photo-cell, which is particularly fussy about the colour of the light that falls upon it. Stains, however faint, especially of yellow, are sufficient to render the cell inoperative or cause a

background of noise on the film. It is for this reason that the American method of never letting the film emerge into the air until it is ready to be dried is finding increasing popularity, because there was undoubtedly a risk of the developer on the film being affected by the air as the film passed from one tank or tube to the other. These very faint stains did not matter with the silent picture, but are, as we have seen, very dangerous to the successful treatment of sound-track.

The latest processing machines have horizontal tanks in a further endeavour to facilitate the passage of the film from one solution to another.

Special precautions are being taken to see that the developer which is losing its strength is replaced in as gradual and regular manner as possible. This is, of course, arranged for in the Lawley machine. The old method of draining off the old solutions and pouring in fresh would be fatal to the sound-film; very strong solutions of developer are being used, and an elaborate system of circulating pipes has been devised to see that the strength is maintained without any sudden changes.

Automatic electrical arrangements keep the solutions at exactly the correct temperatures.

A rather unexpected source of trouble was

found when the first sound-tracks were run through ordinary processing machines; this took the form of distinct hum in the loudspeaker. A series of experiments showed this to be due again to the ever-present enemy, *stain*.

The trouble was traced to the fact that a certain amount of developer was caught up in the perforations at the side of the film, and when the film was lifted out of the developer, this emerged from the perforations and drained on to the sound-track, causing stains due to the slight extra development which it effected wherever it fell. This has now been overcome by plunging the film straight into a bath of a special chemical which destroys the power of any developer which may be left on the film and prevents it doing any damage if it does emerge after the film has left the tank or tube, as the case may be.

Particular care has had to be taken to see that the water in these processes does not contain any small particles which, by being deposited on the film, may cause background noise.

The difficulty of the different degrees of contrast demanded by the sound-track and the picture is greatly simplified, from the developer's point of view, if separate films are used, because it is then possible to develop the two films to their indi-

vidual contrast requirements and arrange to print them separately on to the final positive film.

A further advantage of the machine over the old-fashioned methods is that there is no risk of what were known as rack marks; these were particularly dangerous to the sound-track because they occurred across the film, that is to say, in a line with the sound-track streak.

The engineers engaged in recording sound on film have, like the manufacturers of gramophone records, discovered that the light-sensitive emulsions with which they work must, like the "wax" of the record manufacturers, be of exceedingly fine texture, for at least two reasons; one being the fact that, if the very fine light streaks representing the higher notes—some of them over 400 lines on less than an inch of film—are to be accurately photographed, absolute smoothness of texture is essential; the other being our old friend "scratch," or, in the parlance of the sound-film engineers, "background noise."

The Eastman Kodak Laboratories at Rochester have been investigating this problem of "background noise," which covers any noise introduced by or through the actual dark-room processes through which the virgin film passes on its way to the theatre projectors.

Some of the earlier workers were inclined to believe that the noise was due to optical irregularities in the actual celluloid film "base" before any light-sensitive emulsion was put on. A series of experiments was carried out on several kinds of film base besides that normally used for cine work.

One of these experiments was to run various samples of film "base" through a sound projector in the usual manner. The results obtained by various observers showed that the earlier theories were not correct, and that the trouble was not in the material of the base.

It was found, however, that a considerable amount of noise was introduced if finished film was run through the projector a few times, and that it was rendered more noisy still by being handled with bare fingers.

The next step was to determine how much, if any, "background noise" was increased by the several steps involved in manufacturing the film, and in the ultimate processes of developing, fixing, washing, and drying. The method in this experiment was to run a sample of film through a standard sound-projector and measure electrically the power output of the film.

If the film is optically true, the power output

from the loudspeaker amplifier will be either zero or some constant value. If, however, the film is irregular, the output from the amplifier will vary and will provide a means of measuring the actual amount of any noise present.

These experiments showed that no dirt or other cause of noise is introduced in the first process of coating the "base" with the material by which the eventual sensitive emulsion is secured to it, known as "substrating." When, however, the film was emulsion coated, and put through the regular processes of fixing and washing or developing, the noise was found to have increased.

Steps were then taken to find out whether the increase of noise was due to the presence of the emulsion or to the processing. Two pieces of film were developed and fixed; one was then wiped by machinery, and the other carefully wiped by hand.

The results showed curiously enough that the sample of film which had been wiped by machinery was more than twice as noisy as that which had been wiped by hand.

In order to find out whether a further cause of noise lay in the stages of manufacture, a piece of film, which had been "substrated," but not coated with sensitive emulsion, was subjected to all the

stages of development and fixation; the noise produced by this film was found to be considerably greater than a similar piece of film which had not been developed and fixed. Furthermore, the noise produced by it was comparable with that produced by a sample which *had* been emulsion-coated and "processed" in the ordinary way.

It was clear, therefore, that the trouble lay, not in the stages of manufacture, but in the laboratories of the studios.

Further experiments showed that a film which has been fixed without having been developed is noisier than one which has. It has been suggested that the small amount of fog present in any unexposed but developed film probably tends to mask the noise due to the presence of dirt which has already been introduced, and which causes a larger variation of light falling on the photo-electric cell through clear film than film which has been covered with a uniform layer of silver deposit.

This point of view is rather borne out by further experiments, which were undertaken to find out the amount of noise caused by repeated use in theatre projectors.

It was found that, while the amount of background noise increases in more or less direct

ratio with the number of times the film is run through and rewound, the increase of noise is more rapid with films of lesser density.

Most of us are familiar with the printing frames used for printing snapshots, and many will anyhow have tried their hand at making prints by artificial light on paper which requires developing in much the same way as a plate or film. It will be readily realized that the printing of a strip of twenty or thirty thousand pictures cannot be achieved in an ordinary frame. Special printing machines have long been in existence for this task, but they, like all the rest of the apparatus connected with the film industry, have had to be re-designed for Talkie work.

The principle on which most machines work is very much the same, and they are divided into two types. The "step by step" printer and the "continuous" printer.

In both types the developed negative is contained on a spool on one side of the machine above which is the spool containing the raw positive film, which has to be brought into close contact with the negative before a light, so that the image on the negative can be printed on to the positive. The two films are led by toothed sprockets over a curved "gate" under which the

light is situated, and are then separated again, the exposed positive film being then sent to the laboratory for development and the negative being rewound and transferred to the other side again, ready to make another print.

As we have seen, it is usual to record the sound-track on separate machines and then to print the track beside the picture after the picture has been printed, because the sound-track requires very exact uniform exposure conditions as opposed to the picture portion, which has to be developed and printed to all sorts of degrees of contrast, which vary with each particular scene. The old-time printers were not arranged for any other process than the simple printing of the picture over the whole surface of the film.

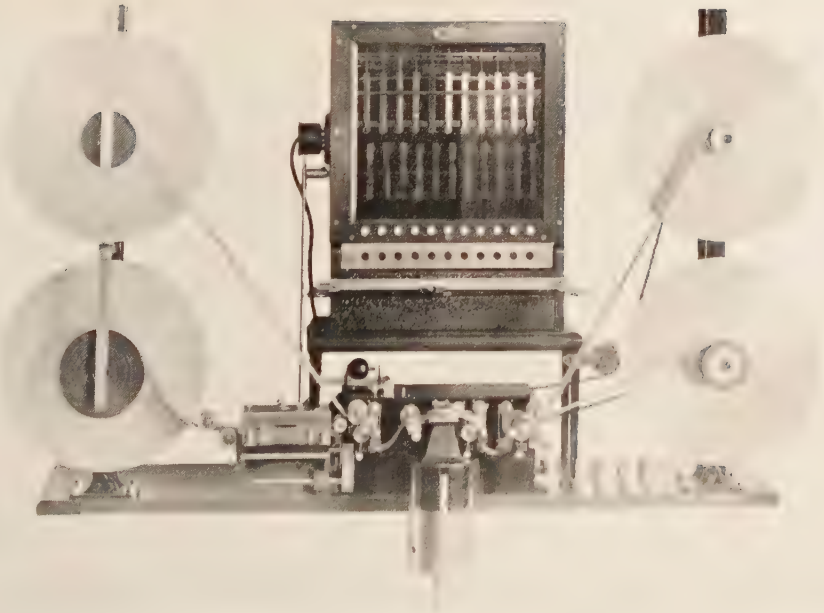
Step by step printers expose the film picture by picture in jerks, differing from the continuous type in that they operate in a vertical direction, the spools being mounted above and below each other, the feed spools being above the "gate"; the light being obscured from the films as they are moving from one picture to another by a revolving shutter, much the same way as in the cameras.

The continuous printer runs the two films smoothly and continuously through past the light.

This latter machine is clearly the only type that can be used for sound-track, but considerable alterations have had to be made before it could be used for the double operation of printing first the picture, and then the corresponding sound-track. The illustration shows the latest type of continuous printer for sound-work. On the left are seen the two spools carrying the rolls of developed negative and raw positive film, the negative occupying the bottom spool, while on the right are seen the spools which collect the exposed positive and the negative respectively.

This printer is so arranged that it will perform three operations at will—print the picture *with* the sound-track in the *same* operation, print the picture *without* the sound-track, automatically masking the space to be occupied by the sound-track, or print the sound-track on to an already printed picture.

A number of points have had to be watched, and various hitherto unimportant refinements made. In order to ensure that the very fine variations of the sound-track could be accurately printed, the slot through which the light shines on to the film as it passes through the light-gate has had to be made very much narrower, and any backlash or unsteadiness has had to be gone into



THE LAWLEY CONTINUOUS FILM PRINTER.

Courtesy of the Lawley Apparatus Co

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with the same care that the camera manufacturers had to bestow on their silent machines for Talkie work; fly-wheels, too, are being fitted to help maintain as constant a speed as possible. Particular care has to be taken to ensure that while the picture is being printed no light can possibly get out sideways through the film on to the portion which is masked off to receive the impression of the sound-track.

This sort of trouble is apt to occur if the sprocket holes are not adequately masked.

The Lawley printer has a particularly clever way of dealing with the different exposures which the various scenes demand.

Tests are made of cuttings from the various scenes to ascertain the best printing exposure for them, and when these have been determined each portion of the negative which requires a different exposure has clipped on to it a tiny metal key; as this key passes past the light-gate it makes an electrical contact, releasing an automatic switch which effects the required change in the strength of light until the next key enters the gate and changes the value of the light to that required for the portion of film for which it is responsible.

With the coming of the Talkies, the whole business of inspecting the finished prints has had

to be altered, and a great deal of additional gear added, for the examiner now has to listen to the film as well as look at it! It is important that the first print off the machine should be heard under theatre conditions, and the inspectors have had to develop an ear as well as an eye!

The joining of films has had to receive attention. It is no longer possible to make the usual quick splice which was perfectly satisfactory for silent pictures, because it emerges from the loud-speakers as a loud "plonk," which is very disconcerting. This trouble has been overcome to a certain extent by two methods of splicing—one avoids the necessity of lapping the two broken portions of the film over each other by bringing the two ends together just as they have broken, and securing them with a strip of clear celluloid stuck underneath them, and the other device arranges for a triangular dab of either black or red paint to be placed over the point where the sound-track is joined, so that it momentarily reduces the light to the cell until all danger of a "plonk" is past.

As in the sound-cameras, the question of vibration has had to be studied very carefully. When these printers came to be used for sound-track, they were continuous printers, it is true, but it

was frequently possible to hear on the finished sound-track the sound of the sprocket perforations as they were engaged by the sprocket rollers which were drawing the films through the machine.

This was found to be due to two causes; the first of these was a purely optical one, and the second a rather unexpected mechanical one.

Troubles are still being experienced due to slight irregularities in the perforations on the film, and it was found that noise and vibration was being caused by the fact that three pairs of perforations were engaged at a time on each side of the film as it travelled through the machine. The first pair were just engaging with the sprockets, the second pair were actually in mesh, the third pair being just on the point of release, thus putting stresses on to the film which caused sufficient vibration to be heard on the sound-track.

The optical trouble was caused by the mask that covered the sound-track section while the picture was being printed. It did not adequately prevent light from getting on to the masked portion by way of the perforations.

In order to avoid these optical difficulties, efforts are being made to allow a margin of about 1 or 2-thousandths of an inch between the

pictures and the sound-track and sound-track and the line of the sprocket holes, a precaution which helps also to prevent the light from getting on to the track edgeways through the film. It is particularly important to see that fogging of this kind does not occur, because the scenes in Talkies are usually much longer than those of silent films, and a re-shoot would be even more expensive than previously.

This chapter, too, might be very much longer than it is, but it is time to call a halt, and to pass on to other matters.

Next time, however, that you go to a Talkie you will perhaps be forbearing if you hear a "plonk" or two, or see the sound-track dancing a Highland fling up the edge of the screen; and you will remember something of the troubles and triumphs of one of the most remarkable industries in the world.

CHAPTER FOUR

THEATRE INSTALLATIONS

Readers will, by now, have formed some idea of the legion of problems which beset the producers of Talkies, who are, however, not alone in this respect.

The theatre proprietors have their troubles as well.

The whole business of picture projection has been modified out of all recognition. The old-time operators had only to see that their machines were giving a clear, steady picture, and that the projectors were maintained in a satisfactory condition.

All that is changed now. The operator, closeted in his stuffy and sometimes hopelessly inadequate little box, rarely visible, except perhaps for a glimpse of his perspiring head stuck out of a window, or merely hinted at by the shadow of his hand across the screen, has become very much more than a mere mechanic. He and his assistants have their fingers on the pulse of the loudspeakers, and, high up in the projection-room, he listens attentively for the signals from his colleagues sitting quietly among the unsuspecting audience. It is they who advise him as to how

things are sounding in the theatre, and tell him when to make the proper adjustments so necessary for the success of the film.

Cinema proprietors will have to readjust their ideas as to how cheaply they can employ men of small *ability*, and by a more bulky pay envelope banish indifference and encourage keen attention to detail, by which alone they can hope to recoup the cost of installing Talkie apparatus.

The chances of having a peep into the operating room of a theatre, especially if it is showing Talkies, are rare. If, however, we were to knock at the door and enter armed with a pass from the Manager, we should have to stand still for a moment while our eyes accustomed themselves to the gloom within; we should then realize that the sharp stabs of light which stared at us like eyes out of the darkness were coming from the giant projectors standing in a row, trained like guns through the iron-clad shutters on to the glistening screen a hundred feet below. Gradually we should be able to make out the crouching figure of an operator, half sitting, half standing, beside a projector, peering intently at the screen, his face lit up by the unearthly bluish light from the inspection window in the side of the enormous machine he is tending.

A voice out of the darkness says, "Stand by," and, as we watch, a second machine stammers and splutters into action, revealing a second figure listening intently to the purr of the driving motor as it wakes into life and settles down into a steady hum. "Get ready," says the voice again; and we stand back, and instinctively flatten ourselves against the wall. "Now," raps out the voice again; down clangs one iron shutter and up goes the other as the second machine takes up the tale and the first operator straightens himself up and slips off his stool, to shake us by the hand and nod a rather weary greeting to his chief. Glad to get away from the squawking of the checking loudspeaker overhead, we slip down into the "house" to hear what the "stuff" sounds like. As we stumble among the familiar rows of seats, our minds go back to those silent figures in their gloom-wrapped aerie, peering unblinkingly into the darkness below; and we begin to realize how practically everything that happens in the "front" of the house is controlled by these men. When we return to the operating box we find the chief seated in front of the electric reproducer, pouring a torrent of interval music into the auditorium; while the machines are being loaded with the next silent picture, and the records which have

been selected for its incidental music are being checked over.

At a sign from the operator in charge, someone goes over to a switch on the wall and the lights below fade from one colour to another, until, on the word "open," we catch a glimpse of the red-plush curtains sweeping apart, as the operator beside us starts his electric orchestra with the flick of a switch, and the projector shears the darkness below with its dancing ray of drama-laden light.

These men are the show now. The organ has gone, the orchestra has gone; only the ladies of the lamp and the girl in the pay-booth are left, with her automatic ticket machine, which spits out what you want almost before the words have fallen from your mouth, and pours a jingling cascade of change into your hand as soon as it glimpses the colour of your money.

In manipulating the film the very greatest care has now to be taken to prevent damage to the sound-track, whose microscopic message is magnified nearly a hundred million times before it reaches the loudspeakers. A faint scratch, quite invisible to the eye, may emerge from the loudspeakers as a harsh background of noise which will disgust the most tolerant of audiences.

Operators can no longer whirl their film rewind-

ing machines at the terrific speed to which they have been accustomed; and theatre proprietors will have to recognize the paramount necessity of providing adequate accommodation for the men who produce the show if they are to keep out the dust and oil stains so deadly to the delicate graduations of the sound-track.

From this point of view the gramophone record method of sound-track has much to recommend it under present conditions of commercial usage, for, as I have mentioned, experience of film sound-tracks does not at present justify any belief that their useful life is as long as the picture to which they are giving breath. For it must be remembered that while damage to the surface of the picture portion, caused largely in the past by the careless slapdash methods of operators, can be considerable before it begins to irritate the eye, it requires very little to offend the ear. It is true that, especially with Talking pictures, whose entertainment value is very high even at their present stage of development, the ear becomes more or less accustomed to imperfections; but as time goes on the point when these imperfections become sufficiently noticeable to affect the box-office receipts will be far more easily and quickly reached.

Special care will, in the future, have to be taken to avoid the risk of breaking the film to prevent the point where the film has been spliced emerging from the theatre loudspeakers as a crash which would spoil the most effective scenes, although even in this most delicate operation experience has taught operators that they can delete as many as nine "frames" or pictures without seriously spoiling the film.

It is not for nothing that the Vitaphone Company still favour the utilization of gramophone records instead of film sound-track. At this present stage of development, and with the lack of educational facilities for operators, many of these have not yet realized that they are handling a far more fragile commodity than the picture reels of but a few years ago.

One disadvantage, however, of gramophone records is the fact that if the film breaks badly it is not possible to splice the record to compensate for the shortened film. Blanks have therefore to be introduced into the film so that the mended portions of the film still coincide with the records which are not always, incidentally, entirely unblameworthy themselves, from the point of view of synchronization with a perfectly new film. Not so long ago a case occurred which put the audience

into shrieks of laughter. The man on the screen was engaged in kicking someone else out of the room. He accompanied this violent procedure with honeyed words of welcome which were intended for a character who was yet to be seen.

It is not unlikely that most Talkie theatres will eventually use screens which are sound porous, so that the sound from the loudspeakers will not be muffled. These screens are not, in general, so efficient from the point of picture projection; and there is a considerable temptation to the operators to increase the intensity of their projector lamps to compensate for this loss of efficiency, with serious risk of damage to the films.

Operators will have to keep a sharp look-out for dirty switches and leaky wiring if they are to avoid the troubles from electrical interference over which their compères in the studios have suffered such nightmares.

The same elaborate precautions to avoid electrical interference which are taken in the studios have to be repeated in the theatre operating room. The whole of the system has to be carefully screened in metal boxes in order that not the slightest trace of electrical interference shall be

able to reach the photo-electric cell. Differences of electrical potential from these cells are very small, and very trifling interferences picked up, either directly on the cell or on the wire leading to the amplifiers, are sufficient to cause trouble.

In order to avoid such trouble, and for other electrical reasons, the Western Electric Company, whose sound-projection apparatus is to be found all over the world, actually mount a valve amplifier immediately behind the cell on the projector itself. This amplifier is very carefully screened and suspended on springs in order to avoid vibration. By this method the impulses from the projector are rendered sufficiently robust to allow them to be taken to the rest of the apparatus, which may be installed some distance away.

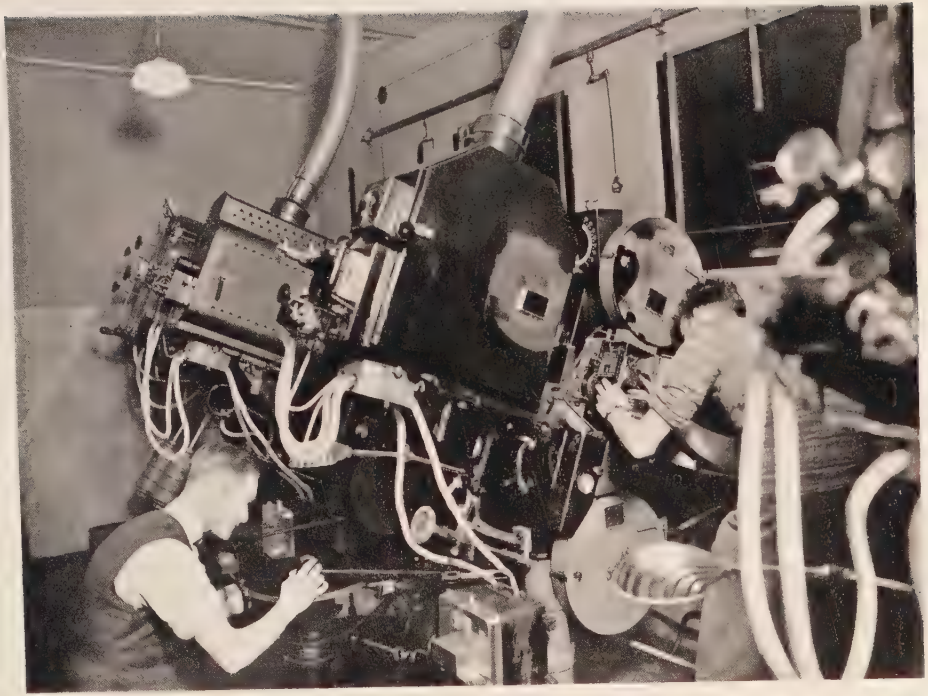
Since the Western Electric Company make provision for disc recording as well as film, their apparatus is manufactured in the form of a base on to which standard projectors may be mounted. This base carries the gramophone turn-table and electrical pick-up, as well as a photo-electric cell attachment for film records. The recording on each successive disc record is cleverly arranged so that it overlaps from the end of one on to the beginning of the next, and the operator is able, by turning a special switch, to fade over from

one to the other, finally transferring the music or speech so that it comes entirely from the new record. This fading requires a good deal of very careful rehearsal, the lack of which used sometimes to be only too painfully obvious. Just as the orchestra or organist must have their cue sheets laboriously worked out before the first performance, so the operators, especially if they are running disc and film, will have to spend a good deal of time on their preliminary runs in order to make sure that they do not make a mistake of a few seconds; such a slip may put the whole of the ensuing record out of time with the film, until the opportunity comes to go back on to the other machine again.

The Western Electric machine provides for the alternative projection of sounds recorded on discs or on either type of film, by the turn of a switch. Where this apparatus scores over some of its competitors is in that a very ingenious unit ensures that the speed of the driving motors are kept constant within remarkably fine limits. That this is of the utmost importance will be realized when it is learnt that a speed variation of only half a part in a hundred is sufficient in some cases to produce a marked change in pitch; an effect similar to that of a gramophone which is begin-

ning to run down, or one which has just been speeded up. The ear is very sensitive to changes of this kind, and a change of pitch of one part in a hundred will be noticeable, if it is made suddenly. The device which effects the speed control is of a nature rather too complicated to come within the scope of this book. But it may be noted that it is a most ingenious adaptation of the principles of tuning known to all users of radio sets, and functions by reason of the fact that any change of the speed of the motors automatically allows less or more power to reach the machines.

The question of speed control is likely to become acute in the smaller country theatres. Many of these rely on a small steam or petrol driven plant, which has hitherto had only to supply sufficient power for the theatre lights and the arc-lamps at the projectors—there are actually still some in use which are turned by hand! Such conditions are naturally quite out of the question for Talkie work, for while the power demanded for the driving motors is small, there is a serious risk that the sudden rise which may occur in the demand on the electrical supply plant, say when the second machine is started up, may cause a momentary drop in pressure, with a consequent drop in pitch of the speech and music



WESTERN ELECTRIC TALKIE PROJECTORS AT THE PLAZA, PICCADILLY, LONDON.

[Courtesy of the Western Electric Co.

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from the loudspeakers, due to the slackening in speed of the driving motor.

Heavier fly-wheels may have to be fitted on to existing engines to prevent such momentary slowing up of the dynamos; and in some cases, where the supply is taken from service mains, which may be too variable, "buffer" batteries will have to be installed to compensate for any sudden increases of load.

Inadequate wiring will have to be attended to, and switch gear which is in any way faulty will have to be carefully overhauled. The price of the present Talkie installations has hitherto prevented the smaller houses from considering the possibility of using them; and a large number of concerns have seized the opportunity to produce a variety of cheap installations for the smaller houses. Many of these are not likely to have a very long life if they do not provide adequate means of stabilizing the speed of the machine. Nearly all use disc records.

The film passes through the projector at a speed of ninety feet per minute, and is provided with the necessary loops to ensure that after it has passed through the picture gate it is able to stream past the photo-cell at a perfectly regular speed.

When disc records are used, the sounds from them are translated into electrical impulses by an electrical sound-box most carefully designed to eliminate undesirable resonances. This is effected, as we have already mentioned, by so designing the component parts that any resonances are of such a pitch that they do not cause audible trouble in the reproduction of music and speech. In one case, the whole interior of the device is filled with oil. The discs are considerably larger than those used in ordinary gramophones, and are, for reasons which we have already discussed, played at a very much slower speed. They will play for ten minutes, which is sufficient to last the run of a standard 1,000-foot length of film. Although it is not often that even 4,000 vibrations per second are projected in practice, these discs also differ from the records usually used in that the needle starts its journey near the middle and travels outwards, finishing up at the extreme edge of the record. The reason for this is that it is at the centre of the record that the needle is required to be most efficient, because the fine "wobbles" of the higher notes are cramped up by the small diameter of the track at that point on the record. It is to secure that the most difficult part of the record may have the

benefit of the needle when it is in its best condition that the record is played from the centre outwards, instead of the usual method of starting from the outside and working inwards towards the centre. This is undoubtedly the best arrangement; but it is not possible to use it on records made for domestic use, because, especially when single-spring motors are used in the cheaper gramophones, it is at the end of a record that the motor begins to lose strength. If the record were to finish at the outer edge, the majority of springs would not, in their exhausted state, be able to cope with the additional work required to pull the record past the needle at the greatly increased speed at the outer edge of the record, the surface of which is travelling very much faster than it does near the centre.

Disc records, however, do not, as we have said, in practice produce very much over 4,000 vibrations per second at the best of times, and there is a noticeable lack of consonants which can produce a most unnatural and woolly tone to many speakers' voices. The most optimistic published details of disc sound-records show that the films are capable of a far wider response, although the "His Master's Voice" engineers have recently produced a most remarkable disc apparatus

which is in every way as brilliant as film records in their present stage of development.

The illustration of an early B.T.P. sound-projector shows clearly the path that a sound-film record follows through the machine when that method of projection is employed, the position of the photo-cell being clearly shown. It will be noticed that the sound-reproducing apparatus is situated some distance below the picture-lens system; and for this reason the sound-track relating to any particular picture is not immediately opposite that picture, but some 14 inches ahead of it, the whole track being printed ahead of the pictures by this distance.

Two machines are usually installed, so that as each reel of film is finished, the other machine can carry on without disturbing the continuity of the programme. This operation is accomplished, as I have mentioned, by the fader, which enables the operator to pass on the next record to the loudspeaker gradually.

This fader is seen in the accompanying illustration.

In the case of the Western Electric apparatus, the main valve-amplifier, whose duty it is to amplify the sound from the photo-cell amplifier mounted on the machine, is divided into three

THE "FADER."

[*Courtesy of the Western Electric Co.*

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THE HIGH POWER LOUDSPEAKER AMPLIFIER.

[*Courtesy of the Western Electric Co.*

[*To face page* 131.

portions. The first unit consists of three amplifier valves, resistance capacity coupled, which feeds into a second unit consisting of two further valves arranged in the well-known "push-pull" manner. This in turn passes the music and speech to the last high-power bank of valves, which feed directly into the loudspeakers. This last valve-panel does not require any batteries whatever, being supplied with the necessary power directly from the main electric supply.

The indifferent results so often heard when Talkies are shown must not be blamed entirely on the projector system, limited as its frequency response at present is. We shall see presently that the shape of the hall and the materials of which it is built can make or mar the effect of any sound-film or disc record, however good it may be.

There has been in the past a tendency to run the loudspeakers so that they give a volume quite unnecessarily great for an attentive audience. This is largely due to a rather natural desire on the part of the operators to get all they can out of the installation. Quite apart from the obvious fact that a bellowing loudspeaker can rapidly become intolerable, there is another reason why a good deal more moderation should be exercised. If sounds are very loud, there is always a tendency

for the lower notes to overwhelm the higher ones and mask them, with the effect that the higher notes and harmonics, which we have seen to be of the greatest importance, are largely rendered ineffective. This effect is particularly noticeable in boys' and women's voices, because not only are the harmonics which characterize their voices higher, but they are fewer and far weaker than those present in the voice of a man. This is quite apart from the general principle that these higher harmonics are of vital importance to that clearness of diction which is a prime necessity if Talkies are to be seriously considered as a form of entertainment. It has been suggested that two separate amplifiers should be employed, and that a special loudspeaker should be allocated to deal with the higher frequencies alone, in order to give them their proper emphasis and compensate for the fact that they tend to get lost not only in the theatre but in the studios. There is the further consideration that, as we have seen, there are photographic and gramophonic troubles to be contended with, when it comes to the recording of these more rapid vibrations.

The Western Electric Company prefer to use horn loudspeakers, and there is this to be said for them; that where "blind spots," which we

Two Western Electric Loudspeakers (a Screenhorn and Small "Monitoring" Horn).

[*Courtesy of the Western Electric Co.*

[*To face page* 132.

shall discuss a little later, are encountered, the directional effect of the horn-type speaker has great advantages. It is obvious that a horn can be directed towards any particular part of a theatre in which reception is poor.

Another claim for these loudspeakers is that their directional properties enable them, if they are mounted behind the screen, to create the illusion that the sound is actually coming from the actors seen on the screen.

Some consider that every possible means should be employed to create this impression; and others believe that, as the public has had to adapt itself to the silent picture, so it will adapt itself to the Talkie, wherever the loudspeakers are placed.

There is one difficulty which seems likely to support the latter view. In large theatres there is the distinct possibility that, if the loudspeakers are all situated behind the screen, the audience at the back of the hall may find that the sound from the screen speakers might have to travel so far that the words would arrive out of synchronism with the movements of the lips of the actors on the screen. This has indeed already been noticed in some halls. This is precisely what happens in the case of actual speakers on a stage. The audience,

however, is in that case not on the look out for it—a rather subtle matter of psychology.

Although there are two schools of thought as to the relative merits of horn and moving coil loudspeakers and their position, there is a strong tendency, not only to use horns, but to bunch them together even more closely than they were before. The experience of the most successful Talkie projector installation concern, the Western Electric Company, cannot be ignored. There was at one time, however, a tendency to go over to the moving-coil type, and the Radio Corporation of America still uses them, it being argued that while the moving-coil type requires a little more attention, it is far more easy to design a speaker of this kind for given conditions than one of the horn type; moreover, the horn is itself expensive to make if it is to give adequate results, and it is also very bulky. This is a serious consideration if the speakers are placed behind the screen, on a stage which is required between films for variety or vaudeville turns, or for one of those picturesque prologues which are nowadays staged before a big film. The lift manufacturers in America have been busy designing loudspeaker elevators, one of which is shown, which enable the stage manager to whisk them up into the roof or move them on

A Movable Horn "Tower."

[*Courtesy of the Western Electric Co.*

[*To face page* 134.

one side, if he wants the stage for other work. The moving-coil type can, however, be installed round the edge of the screen and remain in position out of the way, whether in use or not.

When film recording is done on Western Electric apparatus, the variable *density* method is used; doubtless this Company consider that this method is the best. That view is, however, not held by the Radio Corporation of America, who not only use coil-driven loudspeakers, but maintain that the variable *area* method of recording, which they employ exclusively, is capable of a greater range of sound reproduction than the variable density method. There is, moreover, the undoubted advantage that this form of film record is far simpler to handle from the point of view of printing and development. The difficulty that the variable density film, with its delicate graduations, requires a different contrast treatment to the picture portion, does not arise when variable area records are made; because the sound-record is, as we have seen, either dead black or practically clear celluloid.

The projectors of the Radio Corporation of America are also capable of handling disc records, a device being provided for maintaining a constant speed in the projectors. This consists of a revolving

governor mounted on the shaft of the driving motor—not unlike that used on a gramophone, with the exception that, instead of there being a friction brake, a variable electrical resistance is controlled by the governor, which allows more or less power to pass to the motors. This arrangement is, it is claimed, in every way as efficient as the electrical drive of the Western Electric Company, and it has the advantage of being extremely robust in construction.

From the point of view of the owners of picture houses, the apparatus produced by the Radio Corporation of America has the great merit of being cheaper than the Western Electric apparatus; and there is no reason to doubt that the results from a bank of modern coil-driven loudspeakers more than justify their installation, and that they are at least as capable of giving accurate reproduction as the trumpets of the Western Electric system. The public will in the long run say on what machines they prefer their Talkies projected.

The horn is capable of producing a greater volume for a given power input; but it is quality, and not a superabundance of quantity, that is wanted; and there seems little doubt that the moving-coil speaker, with its power of wide sound

dispersions, will continue to find favour among Talkie experts.

Already one big London theatre Manager reports that he has been inundated with letters thanking him for not showing Talkies; and other cinemas are adopting the policy of showing half Talkies and half Silent programmes. If this sort of thing continues, the manufacturers will have only themselves to blame.

The tendency to design apparatus so that it will give a performance that is just good enough to make money is to be deplored, although the enormous expense involved in experimental work offers some excuse for this attitude. What is wanted is a constant striving after better and better reproduction.

It is to be hoped that the advance and commercial application of this science, at least, will not be arrested because it has reached a stage when the financiers are satisfied that they will see their money back with interest.

If Talkies are to be a success, better reproduction will have to be the order of the day; and the sooner the makers of projectors realize that their audiences will not put up with more than an experimental period of the squawks that are supposed to represent voices, the better it will be

for the art. For there is no reason why the "Talking Picture" should not be an art in the fullest sense of the word.

A well-known film magnate and erstwhile proprietor of a very large number of picture houses, who recently addressed a gathering of electrical and radio engineers, laid considerable stress on the fact that, while he and his associates were fully capable of producing films, they would not be successful until those whom he was addressing had produced efficient valves and loudspeakers. In other words, it was "up to them" to make Talkies a success. It was pointed out to him that, however good the films and loudspeakers were, a very great deal depended on the theatre in which they were being exhibited. His reply, that a hall which was good for a voice was good enough for a loudspeaker, indicated that at least one cinema proprietor had a good deal to learn; and that he was evidently quite unaware that the British Radio and Electrical industry had the production of the apparatus he required well in hand.

A large number of picture houses, especially in the provinces, were not built primarily for sound. Many are long tunnels of buildings with curved roofs, crowded in a narrow space between

shops and offices in busy thoroughfares. The installation engineers are already beginning to find this out. Halls built as theatres, with at least some eye to their acoustic properties, are proving an easier problem than those with large expanses of smooth wall, bare seats, and thinly carpeted gangways. In such houses it is frequently necessary to have nearly twice as much amplification for the hall when it is full, as is necessary when it is half empty. Walls should be broken up by recesses, pillars, and other architectural features, in order to avoid the need of introducing areas of sound-absorbent material, which, while preventing excessive reverberation, result in unfair suppression of the already unfortunate, yet so important, high frequencies. Very lofty ceilings, if they are more than 50 or 60 feet high, tend to produce echoes which may be most disconcerting. These can, however, be prevented to a large extent by the coffering or recessing of ceilings, and by the provision of surfaces rendered irregular by plaster work and carving of one sort or another. Candelabra and other metal fittings have been known to produce trouble by jingling sympathetically when certain notes are played, an effect similar to that noticeable on pianos, when some ornament is not resting firmly on the top.

Sound, while not entirely similar, has certain points in common with light: it obeys the laws of reflection and to some extent those of refraction or the bending of a ray; it can very readily be focused. If the sound of a chord played on the piano be passed through a prism, not of glass, but of some gas denser than air, enclosed in a film of gold-beater's skin, that chord will be split into its component sounds as surely as light is resolved into the colours of the rainbow when it passes through a prism of glass. This method may even be applied to the analysis of the harmonics that give the characteristic "timbre" to a single note from any instrument.

Sound, like light, will be reflected from hard surfaces as an echo. It will even cause large areas of wall to tremble when they are sympathetic to the sound which is impinging on them; and booming effects will be produced which will destroy definition, or introduce an air of artificiality into the most perfectly reproduced music or speech. Echoes and reverberations are pregnant with trouble for Talkie installation engineers. Walls or roofs which are curved collect the sound and, by concentrating it into narrow rays, focus it only on to certain portions of the auditorium, leaving the rest in a sea of meaningless

echoes and reverberations. The problem is further complicated by the fact that it is at present considered desirable to place the loudspeakers behind the special sound-porous screens fitted in theatres showing Talking Pictures, in order to heighten the illusion that the sound is coming from the screen. Where, therefore, there is an enclosed space behind the screen, this has to be very carefully draped, in order to prevent echoes and reverberations from it reaching the audience instead of the direct sound-wave from the loud-speakers.

The time for which a sound will linger in an auditorium before it finally becomes inaudible is of the utmost importance. If this period is too long successive sounds and syllables of words will, as it were, trip over each other and produce a confused *babel*, the understandability of which is very poor. A shot fired into the open air is heard as a sharp crack, but if it is discharged in an enclosed room, it becomes a booming series of reverbations caused by the sound echoing backwards and forwards between the walls and ceilings. A great deal can be done by the introduction of sound-absorbing materials; and a definite mathematical process has been evolved by which it is possible to calculate with reasonable accuracy,

even before it is built, how long a sound should be allowed to persevere in a hall. This varies for speech or music, so that at the best, theatres can only be designed on a basis of compromise.

This period of time is called the period of "reverberation," and experience has taught engineers what periods are most satisfactory for various kinds of performance. A given sound should not last longer than a second, if speech is to be heard under ideal conditions. On the other hand, 2½ seconds is not too long for the right appreciation of orchestras. Sound-recording engineers have to take all these points into consideration when they are making their pictures, which have to be recorded in such a manner that they will reproduce correctly in any hall of the average type.

The booming nature of a concert hall which is half empty is due to the fact that the hall has been so built, either by design or lack of it, that, unless a full audience is present, presenting considerable areas of several layers of clothing material, the period of reverberation is far too long. The modern cinematograph theatre, with its rows of luxuriously upholstered seats, is not thus furnished entirely for the physical comfort of its audience. The problem of the half-empty hall can be, and is

being, largely overcome by the introduction of heavily upholstered seats and thick carpets. The absorption effect is so high, whether or not anyone is sitting in them, that the other characteristics of the hall, such as the walls and ceilings, can be so designed that the sound conditions are reasonably satisfactory even when the hall is practically empty, the effect of the presence or absence of an audience being rendered of less importance to the acoustics of the hall by the large areas of upholstery which are already present.

Readers who have visited them may have noticed that the walls are split up into panels, and that the ceilings are frequently "coffered" or recessed, with the addition of large decorative gratings. They will realize, after what has been said, that the reason for these things is not a purely decorative one; but that the breaking up of large areas of walls into panels covered with special material prevents undesirable reverberations. The recessed ceilings have the same effect, while the gratings are frequently placed where a point of undesirable echo has been found. Some of them are ventilators; but others, although they look the same, are merely backed by an enclosed cavity lined with thick felt-like materials, which will absorb the impinging waves and pre-

vent their being thrown back at the audience as a blurred reflection of the original sound.

It is not generally possible for the Talkie engineer to make actual changes in the architecture of buildings with which he has to deal. But a very great deal can be done by arranging areas of suitable sound-absorbing material at points where disturbing reflections are found to be taking place. There is a danger, however, that if this is done too much serious distortion may take place due to the fact that there are few materials which do not maltreat the higher notes. Although the principles of acoustic design and correction have been known for many years, there are as yet few who have the experience or the necessary testing apparatus to enable them to render unsatisfactory buildings suitable for Talkie production; and Talkie installation engineers are daily confronted with incredible constructional stupidities.

The importance of rendering buildings fire-proof has, in the past, tended to introduce hard materials which are likely to reflect sounds to a considerable extent. Concrete, for instance, will absorb only a little over one-hundredth of a sound which is directed against it, while such materials as oil-cloth and glass are little better. A method which has been in use for some time

for tracing the position from which undesirable echoes originate, employs a highly polished reflector which will reflect sound and light at the same time. A hissing arc or a noisy spark is placed at the focus of the reflector and the sound emitted by it is then thrown from the reflector in the form of a "bundle" (to use Professor Watson's word) of sound waves. At the same time the light itself is collected and thrown as a ray which strikes the wall or ceiling under investigation, at the same point as the sound-ray. By moving this combined sound- and light-ray around, it is possible by listening carefully, and stopping it when a bad echo is found in some part of the house, to look up and see the spot of light resting on that portion of the wall or ceiling which is reflecting the sound-ray. This method of making the track of sound-rays visible enables the acoustic engineer to cover these danger points with felt or some other sound absorbing material so that the sound is reflected only to a desired extent. Care, however, has, as I have said, to be taken in choosing the most suitable materials; for not all are capable of absorbing the whole range of frequencies to the same extent. Some materials, such as certain thick carpets, will, for instance, absorb

three times as much of the sound of higher notes as they will of lower notes; a fact that may lead to a very serious lack of distinctness.

Not only are the actual materials from which halls are built, or with which they are decorated, of the utmost importance, but very careful attention has to be paid to the question of ventilation and the admission of external noises, which are to some extent linked together. All that was required in the days of the silent film was that the air should be circulated as quickly and efficiently as possible. To-day every method of air extraction has had to be carefully examined, to ascertain what effect constantly circulating eddies and layers of air of different temperatures are likely to have on the reproduction of sound from loudspeakers. The method used in many halls, of removing the foul air from a dome in the centre of the roof, has been found by Talkie installation engineers to be particularly liable to give trouble. Any cross-currents materially affect the sound, and the noise of ventilating fans coming from the ventilator shafts has proved, in certain cases, to be a serious nuisance. This can, however, be largely reduced by lining the ventilation shafts and air ducts with material which has a high capacity for sound-absorption, placing baffle plates across

their extremities and suspending or mounting the fans on vibration-proof materials. Really bad electrical interference, such as that caused by fans or pumps or even lifts, whose motors are not in good condition and are sparking badly, have been known to cause serious interference with a Talkie programme.

The audience will have to be protected from sudden bursts of noise from the street as patrons enter and leave the auditorium; and the old-fashioned curtains, negligently swept on one side with a rattle by one of the ladies with the torch-lamp, will have to be replaced by silent double doors. Faulty ventilation has been known to contribute a good deal to this trouble where the arrangement is such that when the doors into the auditorium are opened, the air pressures cause a noisy rabble of unwanted sounds to enter, which will be quite as maddening as the gusts of wintry air that used to waft round our legs every time a patron entered or left the building. Doors should be arranged so that they close completely. It has been shown that the sealing of the cracks between a door and its frame can effect an improvement of as much as 30 per cent. in its sound-proof qualities.

The art of producing "noises off" has been

developed to an art during the last few years. One remarkable machine, looking like a miniature organ, is said to be capable of every noise from a sob to the buzz of a mosquito, not to mention the sound of horses' hoofs, aeroplanes and gunfire. The sound-film has given a tremendous impetus to this sort of thing; and it is said that at Hollywood a library of film noises of every conceivable kind is being formed, which can be hired for adding to the sound-tracks of new Talkies, as and when required. Everything is included in this remarkable epitome of cacophony, from the roar of Niagara to the throbbing tom-toms of West Africa and Chinese popular songs. The perspiring individual with the coconuts who "did" the horses' hoofs, and furiously wound the wind machine at appropriate moments, threatens to become a thing of the past, except for the super-experts, who, for fabulous salaries, are racking their brains thinking of fresh horrors to add to their collection.

Gramophone records have been used for some time for "effects" in broadcasting, especially for such things as the cheering of crowds, and the noises of animals and birds, such as seagulls. But the sound-film opens up all kinds of other possibilities: who knows that the publishers will

not have to issue their books in film form, so that the public will no longer have to burn unnecessary light of an evening, but will be able to sit back and have the "thriller" read aloud to them, complete with pistol shots, osculations, and throttlings by some golden-voiced expert?

In America the "Smellies" have actually arrived, and the firm of Metro Goldwin Meyer are claiming to be the pioneers of this latest pandering to yet a further sense. As a matter of fact the idea of flooding the auditorium with suitable perfumes at points in the film was adopted at least a year ago in London.

It does not sound, or rather sound as if it smelt, particularly attractive; especially for the unfortunates who happen to be near to one of the machines which are flooding the auditorium with the concentrated aroma of anything from carnations to Billingsgate! And means will have to be provided to remove one smell before the next one comes along!

The idea of "atmospheric" cinema theatres is taking hold, and theatres which give the audience the impression that they are watching their picture in an Italian garden or from a terrace at Monte Carlo, are being built here. This has been claimed as an American invention; but some of us still

remember the old Egyptian Hall in London where so many mysteries were performed twenty years ago. Before long we shall be sitting in real flower gardens, and will be able to gather a poesy or two as we go out, to take home as a reminder of our two hours' stay in Naples, or wherever the genius of the proprietor of the cinema has transplanted us for our modest half-crowns. We may, indeed, be thankful that we do not have to squat for hours on end between narrow box hedges about six inches high, as they have to do in Japan. But we may even have to do that, if the film is Japanese!

CHAPTER FIVE

COLOUR PROJECTION

Colour vision is a very intricate and debatable subject, into the philosophy of which it is not necessary for us to enter here. But it will be well to have some general ideas as to what colour is and how it can be more or less accurately reproduced by photographic means.

Isaac Newton is known to the world at large as the first person who sought an explanation of the everyday fact that an apple falls downwards from a tree; indeed, falls with sufficient force to cause pain if it happens to fall on the face of a philosopher reclining under the tree. From this praiseworthy curiosity followed "The Law of Gravitation," which, subject to relatively small modifications due to Einstein, remains the basis of terrestrial and astronomical Physics. It was a far greater contribution to human knowledge than any that had been made before his day.

Newton also claims attention as the inventor of the reflecting telescope, in which the light rays from a star are collected and brought to a focus by a hollow mirror, instead of by a lens, as in Galileo's telescope. The use of a concave

mirror instead of a lens was another great stroke of genius, inasmuch as one surface of a mirror is easier to grind and polish to optical perfection than two surfaces of a lens, and the question of troubles arising from the passage of light rays through a transparent medium do not arise.

But there is a third debt the world owes to Newton, and that is the one with which we are more immediately concerned. He discovered and to a large extent established for all time the nature and origin of visible colour.

Millions of ordinary men had said: "There is a rainbow; there are red roses, violet pansies, green leaves." It required a Newton to ask: "Why is there a rainbow; and is there any connection between its existence and the colours in a garden?" Millions had also seen splashes of exquisite colour reflected from, or perhaps it would be better to say refracted through, a cut gem, or even a dewdrop lying in the fold of a leaf. They also knew that as the daylight fades colours become faint and indefinite, and finally disappear. They must also have observed that by candle light the colours were in many cases modified almost beyond recognition.

Again it required a Newton to seek and find an explanation for these common happenings.

Men naturally think in terms of daylight, which they have agreed to call white light, and it seems an obvious thing now, after Newton has pointed the way, to assume that the colours we see flashed from a colourless gem in daylight must be in the white light itself.

Newton went to work again logically by allowing a narrow ray of sunlight to pass through a slit in a shutter into a dark room. A band of white light was thrown on to the opposite wall, until Newton placed in the path of the ray the simplest form of evenly cut glass, a three-sided straight prism, with its long edge parallel to the slit. Then a miracle happened! Firstly, the white image of the slit was bent out of its path up the wall, which Newton may quite probably have expected. Secondly, and here is our point of supreme interest, the white image was drawn out into a glorious band of colours, graduating from red at the bottom, through orange, yellow, green, and blue, to violet at the top. Newton had found the explanation of the visibility of colours in nature.

Many great minds have worked on the basis of Newton's discovery. Goethe, Maxwell, Young, Helmholts, and a host of others. But Newton's gift remains for us intact, the knowledge that the

colours of nature or art are only visible to us by virtue of their being contained in the light that falls upon them. Daylight contains them all, artificial light contains them partially and in varying degrees of strength. That is why a housewife wishing to match a ribbon in an electric-lighted shop carries it into the daylight at the door, and why an artist says that he cannot "paint by artificial light." The electric arc gives the light most nearly approximate to daylight in ordinary use; whereas lamps, candles, and incandescent mantles more or less egregiously fail to "come up to standard."

We now ask ourselves: "Why, if all colours are present in daylight, is a rose red, a pansy violet, or a leaf green? Why do we see a signal-light red or green, or even violet, from the same source of light behind it?" And the answer to that query is the first step in the direction of solving the problem of reproducing the colours of nature in projected pictures.

This is the answer. A thing we call red has the capacity for absorbing all the rest of the light and colour from the sun's or other rays, and giving back, or reflecting, only the red rays we see in the rainbow. And the colours of all opaque objects depend on the choice they make as to what parts of the rainbow series, which we call

the "spectrum," they will absorb, and what part they will reflect.

In the same way, and this is very important for our inquiry, the colour of a transparent thing —emerald, port wine, signal glass—depends on what parts of the spectrum it absorbs and what part or parts it allows to pass through it. Thus, if we look at a spectrum, such as Newton produced, through certain green solutions, we only see the middle of the spectrum. The solution will not let red or violet rays pass through it, though it may not reflect them.

It is just worth observing that a liquid which absorbs all but one colour from light passing through it does not necessarily look that colour when seen by reflected light against a dark background. For instance, a tumbler of water into which a little red ink has been poured shows pink, if we look at a light through it. But if we place it in sunlight against a dark curtain, it looks a yellowish green. That is called "dichroism," and is a phenomenon that may become important optically.

Three-Colour Vision

It has been a matter of extensive research to ascertain how the eye receives and passes on to

the brain all the great variety of shades of colour. An analogy may help to make the matter clear. When a tuning fork, or a piano wire, gives out a note after being struck, it is because the steel of which it is made is a very elastic body and continues to quiver, or "vibrate" for quite a long time after the blow fell. If it did not do so we should only get a click; but because it does so continuously and regularly, so many times a second, it shakes the air and causes the same number of impacts of air particles to strike the drum of the ear. If the number is great, we hear a high note; if it is small, we hear a low note. The number of vibrations per second of the highest note on a modern piano is about 128 times as great as that of the lowest note. All the other notes are the result of definite rates of vibrations between these two limits.

Scientists have claimed that, just as the ear can receive and convey to the brain air-vibrations, the eye can receive very much smaller and very much faster vibrations of the mysterious something called the Ether, and that the result of this reception is the sensation of light. By analogy with sound, and it is nothing more than analogy, the rainbow band may be considered like a musical scale. For it is established that there are fewer

vibrations per second at the extreme red end than there are at the extreme violet end. In fact the extreme red rays vibrate only about half as fast as the extreme violet rays. Every intervening stage, orange, yellow, green, blue, etc., has its own rate of vibration; and it is this fact which accounts for violet light being bent further out of the straight by a prism than green light is, green light further than yellow light, and yellow light further than red. On the other hand yellow is shifted out of the straight path less than green, and green less than violet. Hence the separation by a prism of white light, or indeed any coloured light, into its component parts.

The white sunlight with which Newton started can be obtained by allowing the spectrum to fall on to a large cylindrical lens and bringing it to a focus on a screen. The colours then recombine and a single white image of the slit in the shutter is formed.

It would seem then that a white surface is one from which all the colours in sunlight falling upon it in natural proportions are reflected in the same proportions. Whereas a colourless surface, which we call black, is one which absorbs all the colour and reflects none.

Later Young and Helmholts made a very

curious discovery, which was afterwards investigated and applied by Frederick Ives to the production of photographic pictures in true colours. It was immensely important, because it showed that the impression of every gradation of colour, starting with pure white, could be produced by the use of only three colours. Their theory was that the eye had a triple system of nerves for receiving colour vibrations, and that all colour sensations were caused by exciting one, or any two, or all three of these systems more or less intensely.

These three colours, spoken of as "the primaries," are red, green, and violet-blue; all other shades of colour—orange, yellow, yellow-green, greenish blue, even what we call pure blue —can be imitated by mixing green rays with red rays or with violet rays. It is rather a staggering idea that yellow is a mixture of green and red, whilst blue is a mixture of green and violet. It will not work if we try it by mixing paints of these colours; but that is, as Kipling says, another story. Suffice it to say that by letting three bands of red, green, and violet-blue light, which fall off in intensity from the middle to the ends, lap over each other on a screen so that the ends of the green reach the middles of the red and violet, we

can show the semblance of a sunlight spectrum, like enough to hoodwink any but a very experienced optical scientist. It is not the same as a spectrum from a prism; but it looks the same to the unaided eye. And that is all we want.

It is the everyday practice of stage-lighting engineers to produce the effect of white daylight, as opposed to yellow artificial light, by having a close row of footlights with alternating red, green, and violet-blue bulbs.

As there will be occasion to refer to three other colours later on, we may as well deal with them now. They are called "complementary" colours, because they each combine with one of the primaries to complete white light. The complementary to red must contain the other two primaries in due proportion, or we should not get white; it is blue-green. The complementary to green is for the same reason a sort of magenta-pink; and that of violet-blue is yellow.

We must again beware of thinking in terms of paint; for we know that yellow paint and violet paint mixed give a dirty green. We are speaking of actual beams of coloured light, and it is easy enough to show that when a yellow beam and a violet beam fall on a clean sheet of paper the paper appears a pure white.

On the assumption, then, that all tints can be produced by red, green, and violet-blue light, singly, in pairs, or in different proportions of all three, it follows that three photographs taken through red, green, and violet-blue light-filters will, between them, represent everything that is visible in the subject photographed. Frederick Ives made black and white positives from three negatives of coloured subjects taken through three such colour-filters. By a most ingenious triple projecting lantern the three positives are then superimposed on a screen, each by white light passing through the same sort of colour filter as that through which the particular picture was taken. When the three red, green, and violet-blue pictures come together on the screen in perfect register, the result is simply amazing, every detail of line, colour, and texture being reproduced.

The difficulty in applying this process widely lies in the necessity for absolute coincidence, or "register," of the three pictures; a difficulty which is enormously increased in the case of moving pictures.

Ives further applied the three-colour process to the production of transparent pictures, which were "registered" in themselves, and only required one

simple lantern for projection. The method he adopted was most simple and exquisitely ingenious. It was based on the fact that the three complementary colours contain the three primaries twice over:

Yellow contains red and green.

Blue-green contains green and violet-blue.

Pink contains red and violet-blue.

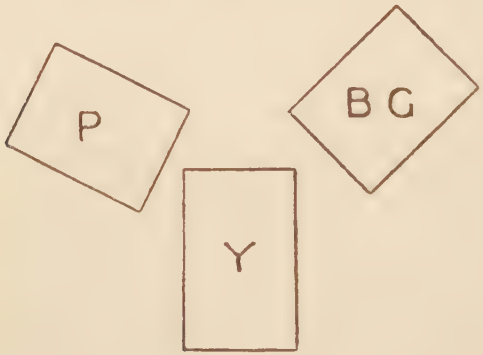
It follows that wherever two transparent films dyed in complementary colours cross each other, one primary colour shows through, namely that which is common to the two complementaries. But where all three complementaries are superimposed no colour at all shows through. Thus a yellow film behind a pink film only allows red light to pass. A blue-green film only allows green and violet light to pass, and stops all red light; that is why it is blue-green. Consequently, when a blue-green is added to the yellow and pink films, all light is stopped; of course, assuming that the films are perfect light-filters.

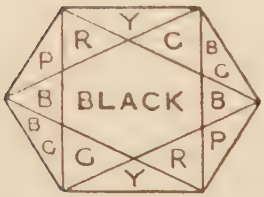
The illustration overleaf will help to make this point clear. Three strips of dyed complementary yellow, blue-green and pink film, cut to the shape indicated, are superimposed as indicated.

The result is a star with a black centre and points

of three primaries separated by triangles of the three complementaries.

The intensity of the complementary dyes, which means the power of stopping their related primaries, may vary very much; these variations





give rise to corresponding variations in tint in the result of superimposing them. Ives availed himself of these facts in the following manner. By a method which belongs more properly to the field of block-process work and need not be explained here, he printed from each primary

In the subject there were	R	Y	W	G	BG	•	P	R	•	G	Y
The red filter negative registered ..	R	R	R				R	R			R
The green filter negative registered ..		G	G	G	G					G	G
The violet filter negative registered ..			V		V		V				
The blue-green positive gave				BG	BG	BG			BG	BG	
The pink positive gave..	P					P	P	P	P		
The yellow positive gave	Y	Y		Y		Y		Y	Y	Y	Y
Referring to the star, we get in the result	R	Y	W	G	BG	•	P	R	•	G	Y

W stands for white, and • for black.

negative a transparent gelatine positive in its complementary colour. The intensity of the colour in the blue-green positive varied exactly inversely with the intensity of the red visible in the object. Where there was a full pure red in the object, there was no blue-green in the positive print; where there was partial red in the subject, there was weak blue-green in the print; where there was no red in the object there was intense blue-green in the print. And so on for all three colours. Each of the three complementary positives viewed through a glass of the related primary appeared to be printed in shades of black and white.

The three complementary positives were now placed one behind the other, with great care to secure perfect register, and bound into a slide between two glass plates. The result was a transparency in which every variety of tint was reproduced with remarkable accuracy. Again an illustration may help to make the matter clear.

Let us place the letters where colours occur in the subject.

This process has been referred to in considerable detail, because it is along such lines that the perfection of coloured moving pictures is being sought.

Colour Movies

One of the very first colour-film processes, which some will remember, was Kinemacolor. Several big films were released which caused no little stir at the time; the films which were best known were those of the Investiture of the Prince of Wales at Carnarvon, and the Delhi Durbar.

The Kinemacolor has long since gone the way of all flesh, but it was a most ingenious attempt to accomplish coloured motion-pictures by a photographic method. Only two compromise colours were used, red and blue-green, the long-suffering eye being expected to supply the rest.

The film was exposed in a special camera at double speed, every alternate picture being exposed through a red or blue-green screen, as the case might be. This was not true colour registry, because each picture was, of course, slightly different from the last; and when objects were moving quickly or near the camera, very weird effects were sometimes observable, notably colour-fringes on moving objects of any light colour.

The projectors on which the films were shown were also run at double speed in order to bring the movement, on the screen, back to normal

pace, and were fitted with a special revolving shutter in front of the lens, which was intended alternately to put a red and green celluloid in front of the projector as the appropriate pictures arrived at the "gate." Unfortunately, this did not always synchronize, and consequently there were flickering fringes of the two colours (not merely due to the fact that no two consecutive pictures were quite the same). Indeed, at least one print of the Durbar showed the remarkable spectacle of a regiment of soldiers marching past, with the red stripes on their trousers and their red coats following along behind them!

Frieze-Greene's colour system was much on the same lines, and he, too, used two colours instead of three, on consecutive pictures. His system differed from Kinemacolor in that he did not rely on the vagaries of a more or less erratic revolving shutter functioning in front of the projector, but actually stained his images alternatively with red and green dyes.

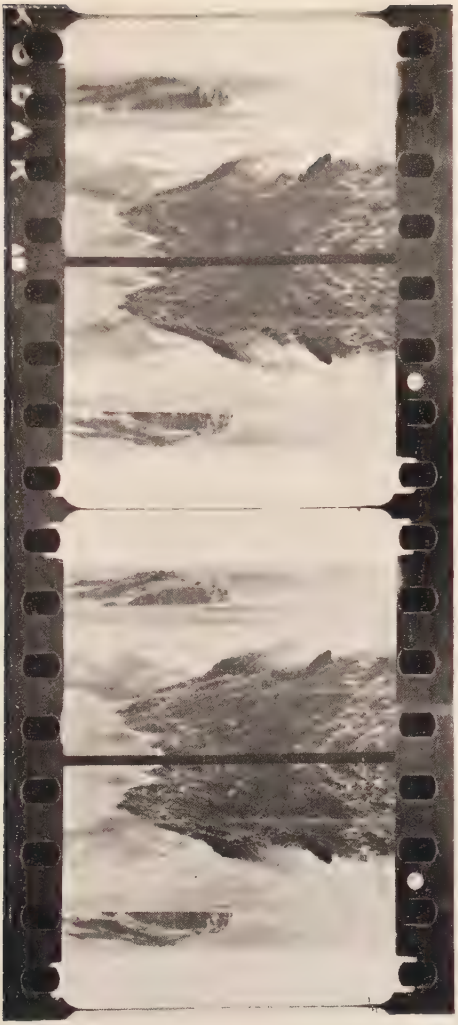
In any colour system that relies on the colour images following each other as different pictures, fringing will be more or less bad. It would seem that the only satisfactory method is to try and put the images on top of each other so that each picture is a complete colour interpretation. As we

shall see later, one British firm has actually succeeded in superimposing all three colour records on each tiny picture.

There was, too, the Pathécolour, which, while giving some very delightful effects, could not by any stretch of imagination be described as true colour photography; for it was accomplished by the almost inconceivable process of actually painting each picture of an ordinary black and white film. Quite a short run of film, lasting not much more than five or six minutes, used sometimes to take three or four weeks to tint, a job which required enough patience to turn Job himself green with envy. It was for this reason that Pathécolour rarely showed anything of a fast moving nature, and confined itself to sylvan scenes and the like, which would enable the "artists" to cut stencils that could be used for a dozen or more pictures before it was necessary to make another set. As it was, trees and objects of that sort usually appeared on the screen with a somewhat indefinite halo of alleged green hovering vaguely round them. This fringe might sometimes intrude on the placid waters of a lake, which in its turn lent the trees some of its blue.

Technicolor is probably the film process best known to cinema-goers, for this is the system used

in photographing Douglas Fairbank's *Black Pirate*, and the colour sequences in *Broadway Melody*, and most present-day American films. In this system only two compromise colours are made use of, orange-red and blue-green. A special camera has to be used. After the rays have passed through the lens, they are split up by a prism into two portions, one set of rays passing through a red-orange screen, and the other set through a blue-green screen, before they are allowed to reach the film. The prism is so arranged that the two images are toe to toe, that is to say, one is upside down and the other is the right way up. As two pictures are being taken at the same time, the camera has had to be specially arranged to move on the film two pictures at a time, instead of one at a time as in the ordinary cinecamera. For this reason the film magazines have had to be enlarged, because the camera uses twice as much film in a given time. The film is very carefully colour-sensitized by means of suitable dyes, so that it will respond to a very wide range of colour, and it is usual, even when working out of doors, to supplement daylight with a few big arc-lamps so as to adjust the colour values to the correct proportions for the film. This has the advantage that it is possible to eliminate shadows where they are not



CONTACT PRINT FROM TECHNICOLOR NEGATIVE. NOTE THE PAIRS OF PICTURES TOE TO TOE.

[*Courtesy of Technicolor Corporation of America.*

[*To face page* 168.

wanted; you cannot shift the sun, but you can shift a few big lamps about so that they take out any unwanted shadows.

The disadvantage of taking two pictures at once is that a considerable amount of extra light is required. The two pictures now have to be printed on top of each other, and the method employed, while seeming very simple in principle, is one of the prettiest pieces of precision work that has ever been seen in the film industry, and took four or five years of concentrated research to perfect.

Unlike the ordinary printing apparatus, about which we have spoken, there are two printing gates instead of one, and two rolls of positive film instead of one.

The negative is passed in contact with one positive *down* through the first gate, through which the red-orange sensation negative pictures are printed, the mechanism pulling down two negative pictures to one positive picture, and thus printing the alternate pictures as a continuous strip. This positive is then wound on to a spool and the negative passes *upwards* through the second gate, where a second positive strip is threaded with it, and the blue-green images are thus printed continuously in the same manner as the red-orange.

The next process is so delicate that it is difficult to believe that it could possibly be successfully achieved for commercial work. The two films are cemented together for the whole of their length in a special machine which brings them together exactly on top of one another. We have already mentioned the troubles due to faulty perforations, and it will at once be realized how vitally important it is that the perforating of the two films should be microscopically exact. This is essential if the sprockets are to lay the two films together correctly in the cementing machine. The Technicolor people have had to make their own perforating machines and sprockets in order to make quite sure that there can be no possible chance of the two films being cemented together wrongly.

The two films are not at all easy to handle, because they are only half the usual thickness of cine film, and are therefore very flimsy. They are led together on sprockets, and as they pass together under a roller, a fine mist of special cement is sprayed on to the two inner surfaces as they close together. The machine is a marvel of ingenuity. The two positives are now cemented back to back exactly in register one on the other, with the emulsions on the outside. They are then

developed automatically in a specially designed machine so constructed to avoid anything touching the surfaces of the film, which is then fixed and washed in the usual way. All surplus moisture is sucked off pneumatically, and the film then passes to the chemical toning troughs. Chemical toning should not be confused with the tinting method used by Frieze-Greene in which one of two dyes was applied externally to the whole of each picture, irrespective of colour detail.

Chemical toning may be done in either of two ways. One is actually to change the colour of the silver image by chemical action, and the other is to dye the silver image the necessary colour by means of a basic dye, which is then "mordanted," or fixed. The silver is then dissolved out, leaving only the dye in its place.

The practical application of this toning process in the Technicolor Laboratories is so delicate that it has to be seen to be believed. It is incredibly clever, and it would seem impossible that so delicate an operation could be performed successfully for so many thousands of feet of film. Each side of the film has, of course, to be impregnated with the necessary chemicals which will tone the image the complementary colour to that of the screen through which it was originally photo-

graphed; this has to be done without the slightest trace of solution getting to the other side only six-thousandths of an inch away. Each side of the film is just floated—that is the only word for it—along the surface of the solutions in a six-foot trough, a process requiring the utmost patience and scrupulous care. It then is dried automatically and sprayed on both sides with a varnish which serves the double purpose of fixing the tones and protecting the film from scratches in the projectors. Where these scratches appear, a flick of either bright red or blue can sometimes be seen, depending, of course, on which side the damage has been done.

There are possible two disadvantages to this system. The first is that the projectors used to-day are designed to keep only one side of a film as clear of friction as possible, the gates and sprockets being arranged so that the film rides on the celluloid only. With Technicolor, however, both sides of the film are important, and there is room for a machine which will protect both sides of the film, and this presents a very difficult problem, because it means that a considerably increased strain would be placed on the sprocket holes, already the source of quite enough trouble.

A further disadvantage of this double-sided film is that with an image on both sides of the film there is a slight out-of-focus effect on the screen due to the thickness of the film base between the two colour images. In other words, if the red side is focused on the screen sharply, the blue side is slightly out of focus and vice versa. A compromise is usually effected whereby at the cost of a slight error in focus of both, an even effect on the screen is produced. This uncritical focus is often mistaken for faulty registration of the colours, but this is not so.

For some years now the Technicolor people have been working upon a new principle to obviate this defect, and have been attempting to bring the colours out on to the same side of the film, and what is more, bring in the third colour, and altogether make a better job of things generally. This new process is now perfected, and arrangements are rapidly being concluded to put it into production; but it is not available at the time of writing.

Among other efforts to get a colour system which put a colour on either side of a film, the now obsolete system known as the Prisma was very much on the same lines. Its sponsors, however, seem to have had some trouble with their

filters, the correct tinting of which is, of course, very important. They must not be so coloured that they give only a very sharply defined colour band, but must allow some graduation of the colours on the two sides; so that they merge and cover the spectrum as gradually and completely as possible.

Multicolor, another American system, follows the Technicolor process in its main features.

An English company, Zoechrome, whose film has not yet been seen in public, has attacked this problem in a most ingenious way, and has, moreover, succeeded in achieving something on which Technicolor are still working; that is, putting three colours on the same side of the film. A camera is used having four lenses cemented in a group (three quite small, and one ordinary size) which photograph four different images of the same aspect at once. The three small lenses have behind them the three necessary colour screens, red, green, and violet-blue, which photograph their respective colour factors simultaneously, but not overlapping on to the space of the one ordinary sized picture. Each colour screen picture is one quarter the size of an ordinary film picture. The fourth lens gets over the trouble mentioned previously, of lack of defini-

ZOËCHROME NEGATIVE.

[*Courtesy of Zoëchrome, Ltd.*

[*To face page 174.*

tion, by photographing an ordinary black and white picture which acts, as it were, as an optical key on which to superimpose the colour images. The fact that four lenses are used instead of one, and that a very ingenious modification has been made to the shutter, makes it possible to do away with the extra lighting usually associated with colour work. The camera can be turned at the speed and under the same lighting conditions as an ordinary cinecamera—a tremendous advantage over other methods. The illustration shows a Zoechrome negative. The coloured positive, of course, in a black and white illustration, would be no different from an ordinary black and white film.

The negative is developed in the usual way, fixed and dried. In printing Zoechrome have again departed radically from ordinary procedure. A projection printer is used, which projects the images from the negative on to the positive, which is in another mechanism, much as an ordinary enlarger treats a snapshot, or a magic lantern throws a slide on to a screen. The black and white key picture of normal size is printed first, the negative mechanism pulling down two picture spaces to the positive mechanism's one. The black and white length is then developed to a half-tone depth, that is to say, to form a grey

and white picture, with no real black, but only varying shades of grey. It is then fixed, washed, dried, and *varnished*. The same film is then recoated with fresh light-sensitive emulsion on top of the grey image, and the first colour-sensation negative is *enlarged* from quarter size to full size, and perfectly superimposed on the top of the half-tone pictures along the whole length. This is then developed, fixed, washed, and toned the *complementary* colour to the screen through which it was photographed. Thus the negative taken through a red screen produces a positive in varying intensitives of blue-green. The negative of the violet-blue component gives a yellow positive, and that of the green component a magenta positive. It will be seen from the above that each toning colour contains the spectrum minus the colour of the photographing filter.

When the first colour positive has been toned with what is known as a basic dye, as distinct from an aniline dye, the dye is mordanted or fixed, and the silver image is then *dissolved out*, leaving only the dye behind, which is absolutely transparent.

A second coat of varnish is applied when the film is dry, and a further coat of emulsion applied to receive the second colour; and after this has

gone through the same process, yet a third emulsion is applied on which the third colour component is printed in its complementary tone.

All this sounds very complicated, but actually it is automatic throughout, and the final result is no thicker than an ordinary black and white positive, whereas it has everything on one side of the film. It needs no extra strength of light to project it, because all the colours are absolutely transparent, being only dyes and not part of the detail or definition of the picture. All the detail and definition of the picture is contained in the half-tone key; so that the colours are only asked to do their normal job, i.e. to colour the parts which should be coloured.

Imagine it. Four separate emulsions, four separate printings and developings, and three layers of varnish so thin that the finished film is no thicker than an ordinary single-emulsion film.

This process is inevitably slightly more costly than that of ordinary film production, but it entails less anxious ingenuity than the Technicolor process involves.

Another British system, Raycol, uses a prism in its camera, as in the Technicolor camera, but in Raycol two colour images are photographed into the space of one ordinary picture. The screens

used are orange-red and blue-green. The system is ingenious in that it does not require a projection printer, because the pictures are printed in their original relative positions. They are combined on top of each other on the screen by introducing a prism, similar to that used in the camera, into the projector lens system; or by means of twin lenses set at a slight angle so as to superimpose both images on the screen.

Polychromide, another British system, works on much the same lines as Technicolor in America, with this difference, that in this system, instead of photographing two pictures at once on the same film, two separate films are used side by side in the camera, and the positive films are dyed instead of being toned.

There is no doubt that colour film projection is bound to come, and there is really no reason why in course of time it should not become very good. But whether or not colour cinematography is ever likely to give results as attractive as the original, each reader must judge for himself.

In the meantime it is rather pleasant to dream of Isaac Newton revisiting the earth, just to see how things are going on, and to watch his face as he sits beside one in the stalls and sees the magic of his prism at work.

CHAPTER SIX

SOME OPINIONS OF TALKING PICTURES

With acknowledgments to the Hollywood and Los Angeles Press.

As I have shown, Talkies have caused a revolution in the motion-picture industry, and like all revolutions it was only popular with those who saw immediate benefit from it. Everyone else in the industry, director, star, cinematographer, and exhibitor, hated the idea of the Talking picture. The only class with whom it was popular was the executive, who saw in this new form of expression a heaven-sent opportunity for making more money and who forced their more or less unwilling staffs to find a way of making Talkies. Although the idea was strange to practically the whole of the personnel of the studios to begin with, the new medium grew upon them as they worked and advanced, until a fascination laid hold on them, with the result that every studio producing Talkies has become wildly enthusiastic about them. Much the same thing occurred with the exhibitor. At the start he saw nothing but enhanced prices for films, with the possibility of the public not "falling for" the new medium of expression. His pessimism has likewise changed to optimism as he sees the long queues waiting

to go into theatres wherever Talking pictures are being shown.

In the Talking picture the director saw the elaborate structure which he had so laboriously built up in the technique of the silent film crashing to the ground, and a new technique taking its place in which, probably, there would be no scope for himself. As we have seen, he was mistaken, and has been amazed to find that he can still incorporate most of those little touches so dear to his heart, and, what is more, has found that the advent of sound has increased their effectiveness rather than diminished them.

Here is what Cecil de Mille, the famous director of the *Ten Commandments* and the *King of Kings*, said: "The microphone is even more merciless than the camera in showing up human imperfections. In silent pictures it was possible to photograph the good side of a star's face and eliminate the bad. That was a godsend, because even the greatest stars possessed one profile that was more attractive than the other, but the microphone makes no allowances. The actor either speaks all words well, or all badly, and that is the way they record. In my opinion many players who have been struggling along for years with only moderate success will suddenly find

CECIL B. DE MILLE DIRECTING A TALKIE.

[*Courtesy of Metro Goldwyn-Meyer.*

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themselves great hits. Wonderful things can be done in sound; that is unquestioned. It is, perhaps, the greatest medium of all. However, in view of the epics already produced, I don't think that the silent form will ever be wiped out. I think it will be the medium for subjects done in the grand manner, of those requiring tremendous pictorial scope and artistry."

His brother, William de Mille, director of the *Doctor's Secret*, the talking-picture version of Barrie's *Half an Hour*, stated in an interview to the *American Cinematographer*, that "in this new school there is no teacher but experience, and very little of that. At present the main struggle is to perfect a craft upon which the future art may be founded. There is a natural tendency at the beginning to rush to the spoken drama for aid, but it is doubtful if this point of view will last long. The photograph of a stage play will not continue to satisfy a public educated to the fluid movement and great intimacy of the true motion-picture. The charm of variety in settings and rapid change of locality need not be lost because the story is told in dialogue. However amusing it may be to theorize on the future development of the Talkie, the real problem which confronts us in the studios to-day is the actual production of

the thing itself. Directors and writers are not yet familiar with those basic conditions under which they must work in the future; it is not the sound-expert who makes the trouble—it is the sound itself. Modern Directors are as dependent upon their 'Mixers' as they have always been on their cameramen. In the present state of the art there will have to be a good deal of give-and-take between the Director and his Mixer. The situation frequently arises in which a perfect recording can only be secured at the expense of dramatic value. It must then be decided whether, at that point, perfect recording or perfect action is imperative. But eventually the Director will become sound-sensitive just as the mixer will become scene-sensitive."

As with the Directors so the stars of both sexes had their anxieties. Would the Talkie mean their eclipse owing to their voices being unsuitable for reproduction? Anyone who has spoken to some of them knows how well-founded this fear was. But this difficulty has already been overcome, because where a star is deservedly popular with the public, but has a voice which is useless for recording, a beautiful "voice double" is supplied and the star goes on his or her way with an unruffled brow. Some of the stars' own thoughts

DOUGLAS FAIRBANKS.

[*Courtesy of United Artists.*

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on the matter make interesting reading. This is what Douglas Fairbanks said: "The creator of a fine bit of work in the Talkie medium will have to be an enormous man. He will have to deal with composition, with movement, with dialogue, with many things. All forms are combined in this new medium. The engineers will stand behind him with their slide rules and insist that he do everything to measure. Dialogue will be used as a means of clarifying the picture, or putting in philosophy. It will be like sugar in a cake. There will have to be just the right measure or the cake will not taste right. We ought to get some really beautiful phrases from great writers and work them into our pictures. If they were spoken well, they would enhance the value of the picture greatly. We have got to find some way to overcome pauses in sound, especially at the ends of sequences, which are so noticeable and horrible. The screen is different from the stage. On the stage the dialogue works up to a climax which is ended by a curtain. We can't do that on the screen for the simple reason that real life, which the Talkies resemble, has no curtains. For that reason my opinion is that stage plays will not be successful on the talking screen. The stage isn't life."

"It is astonishing," said Mary Pickford, who has become so tired of being the "World's Sweetheart," and who has made a sensational comeback in Talkies, "how the new medium rounds out personality. It is as if audiences had been seeing only one side of artistes' faces and now see both. It causes the artiste to become an almost different person. I am making my *début* again. For years I have been seeking a departure from the type of character I normally play, but in every picture up to *Coquette*, I have had to compromise because people would plead, 'Don't destroy that little girl with the golden curls and the innocent heart.' In the development of talking pictures I see all the obstacles that the earliest silent productions had to overcome. In the pioneer days we were troubled with film breaking and with pictures shown backwards; now we get unwanted bizarre effects with sound. We actors are at the mercy of the operators. I am always afraid that they will change me into a bass or baritone. The marvellous thing about the 'Talkies' to me is that they can do away with the two great weaknesses of pictures, close-ups and subtitles. Written titles are always an interruption, a foreign element; they have nothing to do with pantomime. On the other hand, the spoken word plays a vital

MARY PICKFORD.

[*Courtesy of United Artists.*

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CLARA BOW.

Courtesy of Paramount Film Service Ltd.

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part in its relation to the action and assures a continuous flow to the picture."

Clara Bow, star of *Wings*, and possessor *in excelsis* of that mysterious quality known in America as "It," delivered herself thus: "Six months ago I didn't like talking pictures—thought I'd never like to appear in them. I was afraid of something which seemed to be so different from the profession I had learned, but now I know it was all because I had never worked before a microphone. To-day I am crazy about talking pictures, and I hope I never have to go back to silent films."

Harold Lloyd saw added scope in comedy situations and the solution of tremendous difficulties. "Sound is going to help the comedian. It will give him a whole new bag of tricks. Before he had to depend on pantomime alone. Any sound, such as the quacking of ducks, is amusing. We had always tried to obtain such effects for comedies through the orchestra; a drummer who was clever generally added laughs. But, of course, he couldn't approach the results we will be able to attain with the microphone. The possibilities are unlimited. But the problem of producing comedies with sound is terrific. In drama it is difficult enough to keep the charac-

ters moving naturally while the sound is being recorded. In comedy we not only have to do that, but we have to move much faster and meanwhile do gags. The Director having to deliver his instructions by mute signals is a stumbling-block in the performance of the gags, which must be timed to the fraction of a second. The placing of the microphone is another problem. We will have to carry microphones concealed under our coats, or suspended on our backs with the wires hanging down our trouser legs. If we find out how to move freely with the concealed microphones, we can build a whole runway of wires and establish contact through steel plates on the soles of our shoes."

Mack Sennet, producer of more short comedies than any other man in the world, had very decided views on the matter, as thus: "The first thing we learned about talking comedies was that it is bad to have them talk. When dialogue was a novelty we could listen to long-winded garrulous scenes without action, but now it's irritating, and we think: 'For Heaven's sake, why don't they do something.' I like to start a story with a bang and keep it moving. It is best to blend dialogue and sound-effects with action so as to give the audience everything that was done in

HAROLD LLOYD.

[*Courtesy of Paramount Film Service Ltd.*

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CHARLES CHAPLIN.

Courtesy of United Artists.

[*To face page* 187.

silent films and a lot more. I don't think that the 'Talkies' need many people new to pictures. In fact, those that I have already made prove that my best people are motion-picture actors. They know the business, while the stage actor has to be trained. We won't have talking bathing girls, because the record of the average woman's voice is not altogether pleasing."

Chaplin, of course, resides in a motion-picture class of his own. He is probably the one artist in the whole of the motion-picture industry who can stand out against "Talkies" and still remain as popular as ever as the perfect mime. He dislikes "Talkies" immensely, seeing in them nothing but a menace to motion-picture art. From his own point of view he is absolutely right, because one gesture from him tells more than five minutes of dialogue would, but then he is the outstanding genius which the motion-picture has produced, and has a grip of the medium in which he works such as has not been attained by any other man.

Norma Talmadge, like other artistes, was at first by no means decided about the Talkies: "If a person drank coffee for breakfast every morning for ten or fifteen years and suddenly changed to cocoa or tea, it might be rather difficult to become accustomed to the transition. Naturally I am still

a bit 'on edge' regarding 'Talkies,' but I am interested in them—decidedly so."

Joseph Schildkraut, star of *Show Boat*, voiced the feelings of the actor with both stage and screen experience, thus: "Even stage players have to watch their step in dealing with the microphone. Especially is this true of the old-timers who trod the boards when the technique called for voice volume that would crack the eardrums in the last row of the gallery."

Then there were the Art Directors too. When Talkies first arrived they saw nothing but menace in a situation which demanded that all the sets should be built of a new material which had a high sound-absorption factor, and that they should take a form which allowed of no "dead spots" of reverberation. As they have worked in the new medium so they have found a new expression in their "sets," and the evasion of the "dead spot" shapes has given them fresh ideas for the actual composition of their scenes. One of the most elaborate Talkies yet produced, from the point of view of art direction, is *The Broadway Melody*, and Cedric Gibbons, who was responsible for this branch of the picture says: "No matter how engrossing the dialogue and sound-effects may be, we shall not be able to forget that primarily

we are looking at pictures. The backgrounds and composition must appeal to the eye. All of us see a lot better than we hear; in fact, we actually see before we hear. Why did we, as children, always want to look at the pictures when mother read from a story book? Because what we see makes a big impression on us. I do not think any talking picture that completely sacrifices pictorial quality will be successful. There are a number of reasons why our sets for talking pictures are not as elaborate as they should be at the present time. Building sets of proper acoustic material, for instance, costs about twice as much as building ordinary sets. Another difference is that in a sound-picture no two walls may be constructed facing each other on account of the echo. The medium itself, however, offers great possibilities for future development."

Lastly, we come to the cinematographer. This highly specialized technician saw in the conditions imposed by the talking picture his own province being restricted to allow for the sound-engineer to come in, and the knowledge and camera tricks which he had accumulated over a period of fifteen years thrown to the winds, and his own technique made subservient to that of the radio man. Being a combination of artist and scientist,

he saw in the introduction of the new medium nothing but an ugly interloper, one who would negative all his artistic effects and put a veto upon the scientific use of the camera by which he obtains such bewildering results. It was undoubtedly a fact in the earlier talkies that the cinematographers' work was sacrificed on the altar of sound. One very prominent member of the American Society of Cinematographers published in their magazine a bitter indictment as to the cavalier way in which everything except the sound-record was being treated. He complained that: "Apparently the 'talk' in 'talkie' is being counted upon to overwhelm our sense of hearing with fascinating sound to such an extent as to leave all powers of perception relatively numb to visual stimuli, good or bad." He quotes the story of a farmhand who was instructed to grease the wheels of a wagon. He did the job, and later on it was found that he had only treated the front wheels. When asked the reason, he said that as long as the front wheels went round the rear wheels just *had* to follow; the simile being that in the new sound-picture situation sound is the front wheels of the wagon, and cinematography the rear.

Another famous cinematographer saw the

sacrifice of all beauty in pictures to the sound-record. "One must remember that the present high standard of efficiency in the photography of motion-pictures is the result of many years of painstaking research, devotion to ideals, and much expenditure of capital. Shall the beauty of the film, then, be sacrificed to the exigencies of sound as they exist according to present-day sound-picture technique? Beauty, it may be said, is the enchantment, and to permit anything to impair it would seem to be throwing away treasure beyond price."

Not long ago, in one of the large Hollywood studios, the cinematographer in charge of the production was discussing the problems of obtaining better photography in the sound-sequences, when the sound-engineer gave tongue thus: "To hell with photography! What about sound?" Admitted this is not the right spirit in which to attack the problem of a job which demands co-operation from two highly skilled, but utterly different types, of professional men; but there is something to be said for the sound-engineer, who certainly has a tough problem to tackle. To quote one of them: "Apparently some of the motion-picture actors, directors, and cinematographers, seem convinced that all it is necessary to do to

make a talking picture is to substitute dialogue for titles, shoot the picture with finished silent version technique, and have the sound-experts swing a lot of 'mikes' round above the camera line, and record. Now let me give you an analogy. . . . Suppose, for example, that the motion-picture industry with its present highly developed technique and art was suddenly called upon to go on to the so-called legitimate stage and shoot silent versions of stage plays. Then suppose the stage-managers stipulated that the motion-picture experts must improve their equipment and revise their methods so that they could do a passable job of photography without changing one iota of stage action, lighting, actors' make-up, design, and arrangement of sets, and, furthermore, that the cameras must shoot from some fixed sideline so that the audience cannot possibly see them. Cannot you plainly hear the tremendous howl which would go up to high heaven from the cinematographers and picture directors? Yet this is a perfect analogy of what we sound-engineers are expected to be able to perform on the studio floor."

The cinematographer, being above all things an adaptable fellow, as well as a scientist, has, however, found in the sound-engineer an indi-

vidual who commands his respect, inasmuch as he certainly is working under adverse conditions, and, what is more, getting results. The sound-engineer, in his turn, is beginning to get some idea of the cinematographer's point of view, and, realizing that both photography and sound must work hand in hand, and that one is as necessary as the other, the two are now working in happy co-operation.

What would they say now? Perhaps they are all too busy getting down to their new problems to have time for contemplation. Whatever people may say, the Talkies are improving. Slowly, but surely, the back stage "sob stuff" with its pink and blue heroines is dying out, and the prime importance of a sound plot, good words, and balanced acting, is becoming evident. Rubbish seen alone or heard alone does not stand out so sharply as when it is caught writhing in the converging beams of simultaneous sight and hearing. The screen is tending towards reality. The Talkies have brought it marvellously near on more than one occasion. It is easy to deplore an age of mechanical entertainment, but there is no doubt that science and reality can be, and are being, brought closer together by the talking picture. There can be no better ending for this

book than a quotation from an American film engineer, Mr. J. W. Coffman, speaking in America to the American section of the Society of Motion-Picture Engineers:

> Science and Art are not natural enemies—rather, they are natural complements. Science reveals nature—art makes life liveable in spite of those revelations. Science represents the accomplishments of man—art, his aspirations. . . . And as aspiration tends to become accomplishment, the art of to-day becomes the science of to-morrow. And yet, paradoxically enough, art begins where science ends, for the foundation of all art is science, whether that science be conscious or unconscious. Art is empirical—science, mathematical. Science seeks realism—art seeks illusion. But, for the tools to create illusion, art turns to science, the sturdy champion of reality.

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